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Area 19 snow crab, *Chionoecetes opilio*, stock assessment in the southeastern Gulf of St. Lawrence in 2003

Évaluation de stock du crabe des neiges, *Chionoecetes opilio*, de la zone 19 dans le sud-est du golfe du Saint-Laurent en 2003.

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ABSTRACT

The 2003 assessment of the southeastern Gulf of St. Lawrence snow crab, *Chionoecetes opilio*, stock (Area 19) was done based on data from the commercial fishery (fishermen's logbooks, at-sea observer's measurements, purchase slips from processing plants and quota monitoring reports) and trawl survey.

In **Area 19**, the 2003 landings decreased by 5.7% (3,103 t) compared to 2002 (3,279 t). The fishing effort decreased by 46 % in 2003 (29,952 trap hauls) compared to 2002 (46,828 trap hauls). The fishing effort was widely spread all over the area in 2003. The average CPUE increased from 72.3 kg/th in 2002 to 103.6 kg/th in 2003. The annual percentage of soft-shelled crabs was 3.7%, the same level as the previous year. The mean size of commercial-sized crabs in sea samples increased from 110.0 mm CW in 2002 to 114.0 mm CW in 2003.

The 2003 survey biomass index of commercial-sized crabs (8,080 t ± 18 %) has increased by 64 % compared to 2002 (4,930 t ± 30 %) to reach the highest level recorded since we began conducting the trawl survey in 1990. This survey biomass index is composed of new recruitment to the fishery (50 %) and is estimated at 4,070 t ± 24 %. The abundance of prerecruits R-3 and R-2 has been decreasing which may indicate a reduction in commercial biomass index in the near future if no immigration of adult males ≥ 95 mm CW occurs. The female-male ratio is at a level that seems more favorable to reproduction compared to the southwestern Gulf of St. Lawrence. Using the historical exploitation level of 63 % seems to be beneficial in terms of female-male ratio and reproductive output and would also promote an accumulation of residual biomass for the subsequent fishing seasons. Any increase in exploitation compared to the current level may not improve the population's reproductive potential in the future. To protect the future recruitment to the fishery and the reproductive potential of the stock, management measures, such as a soft-shelled crab protocol, are necessary. Also, the continuation of the trawl survey is essential to provide annual abundance and commercial biomass indices, detect any anomalies in reproductive potential of the stock and estimate the loss or gain of commercial sized crabs between the time of the survey and the next fishing season due to natural mortality, emigration or immigration. The trawl survey is considered the major tool in assessing the snow crab stock in the southern Gulf of St. Lawrence.

RÉSUMÉ

Le stock du crabe des neiges, *Chionoecetes opilio*, dans le sud-est du golfe du Saint-Laurent (zone 19) en 2003 a été évalué à partir des données de pêche commerciale (carnets de bord des pêcheurs, des observateurs en mer, des bordereaux d'achat des usines de transformation et des rapports de contingents) et des relevés au chalut.

Dans la **zone 19**, Les débarquements de 2003 a diminué de 5,7% (3 103 t) comparativement à 2002 (3 279 t). L'effort de pêche a diminué de 46% en 2003 (29 808 casiers levés) comparativement à 2002 (46 828 casiers levés). L'effort de pêche a été dispersé dans toute la zone en 2003. La PUE moyenne a augmenté passant de 72,3 kg/cl en 2002 à 103,6 kg/cl en 2003. Le pourcentage annuel des crabes à carapace molle a été de 3,7%, soit le même niveau que l'année dernière. La taille moyenne des crabes de taille commerciale dans les échantillons en mer a augmenté passant de 110.0 mm LC en 2002 à 114,0 mm LC en 2003.

L'indice du relevé de 2003 de la biomasse commerciale (8 080 t ± 18%) a augmenté de 64% comparativement à 2002 (4 930 t ± 30%) soit le niveau le plus élevé enregistré depuis le début des relevés au chalut en 1990. Cet indice de biomasse du relevé est composé de nouveau recrutement à la pêcherie (50%) estimé à 4 070 t ± 24%. L'abondance des prérecrues R-3 et R-2 a diminué, ce qui pourrait indiquer une diminution de l'indice de la biomasse commerciale dans un avenir proche si aucune immigration de crabes mâles adultes ≥ 95 mm LC n'a lieue. Le ratio femelle-mâle est à un niveau qui semble plus favorable comparativement à celui observé dans le sud-ouest du golfe du Saint-Laurent. L'utilisation du niveau d'exploitation historique de 63 % semble être bénéfique en ce qui a trait au ratio femelle-mâle et à la performance de reproduction et pourrait aussi permettre à une accumulation de biomasse résiduelle pour les saisons de pêche subséquentes. Toute augmentation du niveau d'exploitation que celle actuelle mise en place pourrait ne pas améliorer le potentiel reproducteur de la population dans le futur. Afin de protéger le futur recrutement à la pêcherie et le potentiel reproducteur du stock, des mesures de gestion, tel le protocole de crabes à carapace molle, sont nécessaires. De plus, la continuation du relevé au chalut est essentielle pour fournir des indices d'abondances et de biomasse annuelles, de détecter des anomalies du potentiel reproducteur du stock et d'estimer la perte ou gain des crabes de taille commerciale entre le relevé au chalut et la prochaine saison de pêche due à la mortalité naturelle, l'émigration ou l'immigration. Le relevé au chalut est considéré l'outil majeur de l'évaluation du stock de crabe des neiges dans le sud du golfe du Saint-Laurent.

Introduction

Snow crab life cycle:

In the southern Gulf of St. Lawrence (sGSL), molting occurs in December-April (Watson, 1972; Conan et al., 1988a; Sainte-Marie et al., 1995; Benhalima et al., 1998; Hébert et al., 2002a), prior to the fishery. Snow crabs molt normally every year until they reach a final or "terminal" molt (Conan and Comeau, 1986). Males undergo this terminal molt (called adult: Sainte-Marie et al., 1995) at sizes ranging approximately between 40 and 150 mm of carapace width (CW) (Conan and Comeau, 1986; Sainte-Marie and Hazel, 1992; Sainte-Marie et al., 1995). Females reach terminal molt at smaller sizes between 30 and 95 mm CW (Moriyasu and Conan, 1988; Sainte-Marie and Hazel, 1992; Sainte-Marie et al., 1995). Pubescent females are identified as being adolescent females (a non-reproductive state) with a narrow abdomen and fully developed orange gonads in the fall. These females will molt to maturity (terminal molt) the following year (nulliparous) characterized by an enlarged abdomen and ripe ovaries and mate and extrude fertilized eggs and become primiparous females (first brood). They mate and extrude eggs for the first time (primiparous) during December and April immediately after their terminal molt while the carapace is still soft (Watson, 1969; Moriyasu and Conan, 1988). Multiparous females are repeat spawners (second brood or older) whose mating season occurs from May to June before and after egg hatching (Conan and Comeau, 1986; Moriyasu and Conan, 1988; Sainte-Marie and Hazel, 1992; Moriyasu and Comeau, 1996; Sainte-Marie et al., 1999). Females may produce more than one viable brood from sperm stored in their spermathecae from the first mating without subsequent mating (Sainte-Marie and Carrière, 1995). However, mating after larval hatching might be a general rule for snow crab as the probability that one male fertilizes a female's lifetime production of eggs is small (Rondeau and Sainte-Marie, 2001). Larval hatching will occur approximately 2 years after mating (Mallet et al., 1993; Moriyasu and Lanteigne, 1998; Comeau et al., 1998). In the sGSL, the majority of mature females seems to follow a two-year reproductive cycle with a negligible portion of mature female population following a one-year cycle as Sainte-Marie et al. (1995) observed in some cases in Baie Sainte-Marguerite in the northwestern Gulf of St. Lawrence.

After molting, snow crab has a soft shell and its content is mostly water for a period of time. It takes about 8-10 months for an adult soft-shelled male crab to harden its carapace (Hébert et al., 2002a) and 1 year to reach maximal meat yield (Dufour et al., 1997). Adult soft-shelled males, not being able to mate during their postmolt period (Moriyasu et al., 1988), will be ready to participate in reproductive activities the following year, during February with nulliparous females and in May with multiparous females (Conan et al., 1988). In addition, adult soft-shelled crabs of legal size represent the annual recruitment to the fishery, as they become commercially exploitable for the following fishing season (Hébert et al., 2000b).

Historic of Area 19 fishery:
In 1978, Area 19 (Fig. 1) was established for the exclusive use of inshore fishermen with vessels less than 13.7 m (45 feet) in length. The number of permanent license holders increased throughout the years from 14 in 1978 to 74 in 1995. Landings, controlled by quota, ranged from 900 t to 1,390 t between 1979 and 1991. Quotas set at 1,686 t from 1992 to 1994 were reached. In 1995, 37 temporary (one year) license holders using 25 inshore vessels fished 134 t of the total quota (1,577 t). In 1996, the 37 temporary license holders were converted into permanent licenses and the 111 permanent license holders fished a quota of 1,343 t. In the same year, a 5-year partnership was signed between the Department of Fisheries and Oceans (DFO) and Area 19 snow crab fishermen's association (Anonymous, 1996). In 1997, the total quota was set at 1,386 t and was increased to 1,991 t in 1998 (the 1998 landings reached 1,988 t). In 1999, the quota was set at 1,986 t (landings of 1,979 t). For the 2000 season, a quota of 3,370 t was set and shared between traditional and temporary fishermen according to the co-management agreement (2,702 t to traditional fishermen and 668 t to temporary fishermen). The fishing season was closed before the temporary fishermen had time to finish their quotas (total landings were at 3,225 t) because of a high incidence of white crab (hard-shelled crab with low meat yield) in landings and also to permit DFO Science Branch to conduct the trawl survey. In 2001, a new co-management agreement for a period of 9 years was signed between DFO and Area 19 snow crab fishermen. The 2001 quota in Area 19 increased to 3,912 t and was shared between traditional (3,618 t) and temporary (294 t) fishermen according to the co-management agreement. The 2002 quota was set at 3,285 t and shared between traditional (2,705 t) and temporary (580 t) fishermen. Landings in 2002 reached 3,279 t. In 2003, the quota of 3,106 t was shared between traditional (2,490 t) and temporary (616 t) fishermen. Landings in 2003 reached 3,103 t. Also in 2003, Area 18 was amalgamated into Area 12 and in order to maximize the protection of the stock, a five nautical mile no fish buffer zone (Fig. 1) for all fleets was implemented.

Historic of stock assessment methods and management strategy:
Prior to 1990, the biomass of snow crab in Area 19 has been estimated indirectly from catch and effort data using Leslie analysis (Leslie and Davis, 1939; Ricker, 1975; Elner, 1982; Mohn and Elner, 1987). In 1990, a trawl survey with a geostatistical data analysis (kriging) was introduced (Conan and Maynard, 1987) to enhance the precision of snow crab abundance estimation and establish sound stock management strategies. New management measures were introduced in 1991. One of the measures used was to determine the total allowable catch (TAC) or quota based on the biomass of adult male crabs $\geq$ 95 mm CW. A second management measure was to avoid soft-shelled crabs in the catches because they are of poor commercial quality, unable to participate in mating and represent recruits for the following fishing seasons. Soft-shelled crabs are discarded at sea by fishermen. They are fragile and should be carefully handled to avoid mortality before being returned to the sea. Monitoring

of soft-shelled crabs in the catches during the fishery can be achieved by using a durometer gauge (Foyle et al., 1989). Since 1997, a protocol for the daily monitoring of the soft-shelled crabs was put in place for Area 19 fishery. The fishery could be partially or completely closed when the average of soft-shelled crabs (in number) exceeds 20% for two consecutive weeks. Since 2002, the protocol for Area 19 was modified to enhance the protection of newly molted crabs for this summer fishery. A new criterion of carapace hardness at 78 units was introduced instead of 68 units for soft-shelled crabs, which is currently used for the spring fishery in the sGSL. The reason for this change is that newly molted crabs (soft-shelled crabs) exceed the limit of carapace hardness at 68 units in the summer. In Area 19, an individual boat quota has been established since 1991 in collaboration with the industry based on the trawl survey results.

Materials and Methods

Fishery monitoring:
Raw data on catches and fishing effort were obtained from the fishermen's logbooks and the sales slips of processing plants. The data were compiled by the Informatics and Statistics Branch of the Gulf Region of the Department of Fisheries and Oceans and re-verified by the Oceans and Science Branch. Not all logbooks were usable. The mean catch-per-unit-of-effort (CPUE) of the fleet at year (i) corresponds to the ratio of total catches from sales slips (where available) or the fishermen's logbooks (y_i) and the corresponding number of trap hauls (th_i) reported in the logbooks: $CPUE_i = \sum y_i / \sum th_i$. The total effort (total number of trap hauls: (TH_i) was then estimated by total landings (Y_i) from the quota report divided by average $CPUE_i$: $TH_i = Y_i / CPUE_i$. The geographic distribution of fishing effort was presented as the sum of the total number of trap hauls within each grid of 5 minutes latitude by 5 minutes longitude. The fishing positions were taken from logbooks. In Area 19, the fishing performance between the traditional and temporary fishermen is different (DeGrâce et al., 2001) and in order to better compare the annual CPUE, from 1998 to 2003, only data from traditional fishermen were used.

Since 1990, DFO has been conducting a sampling program (observer program) on board commercial vessels (Fig. 2) to provide a weekly assessment of the percentage of soft-shelled crabs in the catches. For each trap sampled, the position, depth and total number of male crab were recorded. A sub-sample of 40 crabs was chosen randomly and the following measurements were taken: CW, chela height (ChH), carapace condition (CC: Hébert et al., 1997) and hardness of the carapace (CH) measured at the base of the right propodus with a durometer (Foyle et al., 1989).

The catch composition (% of different categories of crab) was estimated based on the carapace hardness (hard or soft), size (legal and sub-legal), and morphometric maturity (adolescent and adult). The terminology described by Sainte-Marie et al.

(1995) is used in this paper; "adolescent" formerly called morphometrically immature and "adult" formerly called morphometrically mature (Conan and Comeau, 1986). Individuals with carapace conditions 1 and 2 and claw hardness less than 68 on the durometer were considered as soft-shelled crabs (Hébert et al., 1992). The annual and weekly mean percentages of soft-shelled crabs were calculated based on the size distributions obtained at-sea and at-port samplings, then weighted by the landing for each sampled vessel (Hébert et al., 1992).

Trawl survey:
A trawl survey has been conducted since 1990 in the sGSL to evaluate the commercial biomass and population dynamics. From 1990 to 1992, the trawl survey in Area 19 was conducted before the fishing season but since 1993, the trawl surveys were conducted after the fishing season. Since 1990, three vessels were used to conduct the trawl survey in Area 19. From 1990 to 1998, a 65 feet side-trawl wooden boat with 375 HP (Emy-Serge) was used to conduct the trawl survey and from 1999 to 2002, a 65 feet stern-trawl steel boat with 402 HP (Den C. Martin) was used. In 2003, a 65 feet stern-trawl fiberglass boat with an engine of 660 HP (Marco-Michel) was used. No comparative side-by-side at-sea catchability study was amenable among the three survey vessels. However, a comparative analysis of the trawl behavior between the "Den C. Martin" and the "Marco-Michel" was done in terms of the swept area by comparing the net opening, the speed of the boat and the distance of each tow. It was also decided at the 2000 RAP meeting (Anonymous, 2000) that the 2000 biomass estimate from the 1999 trawl survey was not considered to be reliable due to the malfunction of the Netmind® sensors and the difficulty to calculate the swept area by the trawl. This problem was resolved for the 2000 trawl survey by calibrating the distance sensors and adding a Netmind® depth sensor and a Minilog® depth-temperature probe to the trawl to better monitor the touchdown of the trawl net.

A systematic random sampling design was used to determine the location of trawl stations (Fig. 3). One to two locations were randomly chosen among nine sub-grids (station in the middle of the grid) within each grid of 10 minutes latitude by 10 minutes longitude. The center of each sub-grid chosen was used as the position of each trawl station. The starting and ending positions and time of each tow, depth and bottom water temperature were recorded. Once the locations of each tow were determined, they remained fix every year. A Bigouden *Nephrops* trawl net originally developed for Norway lobster (*Nephrops norvegicus*) fisheries in France was used (20 m opening with a 27.3 m foot rope on which is mounted a 3.2 m long, 8 mm galvanized chain; Conan et al., 1994). All stations were trawled during daylight time. For each tow, the predetermined amount of warp was let out (3 times the distance of the depth) and winch drums were locked. The start time of a standard tow was determined when the trawl touched the bottom monitored by the Netmind® depth sensor (signal received at every 7 seconds) and the Minilog® temperature-depth probe (signal received at every 3 seconds) attached to the

trawl. The duration of each tow varied between 4 to 6 minutes at an average speed of approximately 2 knots depending on the depth, current speed and sediment type. The catch of each tow was photographed after the catch had been released to the deck. The horizontal opening of the trawl was measured every 4 seconds with the Netmind® distance sensors. The swept distance by the trawl was estimated from the position (latitude/longitude) measured every second with a DGPS system. The swept surface for each tow was then calculated using an instantaneous surface algorithm (Surette, unpublished). The following information was recorded for all captured individuals: CW, ChH, CH and CC for males; CW, width of the 5th abdominal segment (AW) and CC for females. The color of the eggs of mature females and the color of the gonads of immature females were noted.

A kriging (MPGEOS) program (Wade et al., unpublished) for snow crab stock assessment in the sGSL was used to estimate annual abundance and density contours for both males and females based on their size and maturity status. Using point kriging and a fitted variogram, we generated maps of density and variance contour. We further used block kriging for estimating an average density and variance to estimate the total number of crab present in a given area. The abundance of snow crab estimated by kriging was converted into biomass (called biomass index hereafter) using a size-weight relationship. To convert size to weight, a size-weight relationship was calculated for adult hard-shelled males: $W = (2.665 \times 10^{-4}) CW^{3.098}$ (Hébert et al., 1992). Mortality between the survey and the fishing season (8-9 month period) was considered as null except for category-5 crabs (very old carapace). Biomass index was projected for (1) the total biomass (B) following a given fishing season without considering the mortality for category-5 crabs, (2) annual recruitment to the fishery (R), and (3) biomass of category-5 crabs (OB). The abundance indices of future recruitment to the fishery (R-3 and R-2) were also estimated. The R-3 group represents the adolescent crabs with a CW between 69 mm and 83 mm caught at the time of the survey, which a portion could be available for harvesting in 3 years. The R-2 group represents the adolescent crabs with a CW larger than 83 mm caught at the time of the survey, which a portion could be available for harvesting in 2 years.

Discrepancy in commercial biomass estimates:
Since 1993, a post-fishery season trawl survey was conducted in Area 19 to provide a predicted biomass index for the following year from point density estimates. The predicted biomass index for the following year did not include any mortality factor or catchability factor due to the lack of information. However, a recent review of the snow crab assessment methodology (Anonymous, 2002) indicated that there is a systematic loss in the predicted biomass estimate resulting in a possible overestimation of the population. This may be caused by faulty underlying assumptions, such as 0% mortality (including natural mortality and emigration or immigration) between the survey and the following fishing season, and 100% catchability of commercial sized males by the trawl net. Consequently,

the estimated value generated from the trawl survey data analyses may not represent the absolute biomass or abundance. Therefore, the estimation of mortality rate is necessary so that a more accurate estimate of the available abundance and biomass can be done.

Wade et al. (2003) showed that no significant difference was found in the estimates of the instantaneous natural mortality rates among three statistical approaches: Non-linear least squares regression (NLLS), bootstrap simulation and Bayesian analysis. Consequently, we used the non-linear least squares regression model to estimate the mean annual instantaneous natural mortality rate in Area 19.

The relation between predicted abundance of adult males ≥ 95 mm CW from year y (A_y) to the remaining abundance of adult males ≥ 95 mm CW after the following fishing season and the abundance of adult males ≥ 95 mm CW caught during the season (A'_{y+1} and C_{y+1}, respectively) for year $y+1$ is:

$$A_y \rightarrow A'_{y+1} + C_{y+1}$$

Using delay-difference formula we can relate groups of snow crab from adjacent years to estimate certain key population parameters. Two types of delay-difference models were used to examine the parameters of interest: 1) the mean mortality rate per unit year, and 2) the migration between CFA 12 and CFA 19. The development of the general model stems from the relation above and under its simplest form is given by:

(1) $$A_y = A'_{y+1} + C_{y+1}$$

This equation, under various forms, has been called the forward-backward check formula in past documents (Chiasson *et al.*, 1995; Hébert, 2002b) and is in fact a special case of the general formula (2). It was noted that a unidirectional bias (Hilborn & Walters, 1992) was present in our data. This could be due to a number of factors such as sampling biases in the survey or catch data, migration or natural mortality.

The central interest of the present assessment is to obtain an estimate of the mean annual instantaneous natural mortality rate in Areas 12 and 19. Our general model thus includes two parameters; the mortality rate (M) and the catchability coefficient of the catch gear relative to the trawl (q).

(2) $$A'_{y+1} = e^{-M} A_y - qC_{y+1}$$

Note that q is a proportion while M is a rate per unit time. Assuming in (2) that $M = 0$ and $q = 1$ yields (1). If this assumption held, we would be able to use

stock abundance estimates as unbiased measures of population abundances. However, a systematic discrepancy in our data undermines such an assumption.

Between Areas 12 and 19, it has long been suspected that a migratory influx of crab from the former into the latter exists. Hence, to treat these two zones individually, the migration has to be accounted. Treating each abundance estimate within each zone (or zone grouping) as a single data point, we generalize (2) and include an additional parameter (d) used in conjunction with an indicator variable (I) denoting the zone to which the data belongs.

(3) $$A'_{y+1} = e^{-M} A_y - qC_{y+1} + dI$$

Simulation/NLLS model

Simulated data was produced and analyzed using Analytica™ version 2.0. Each variable (A_y , A'_{y+1} , C_y) was simulated as a lognormal distributed random variable. The variance in the population estimate variables (A_y and A'_{y+1}) is based on the kriging variance. The variance in the catch variable (C_y) was attributed to the standard deviations observed in mean weight estimates from the survey which is then used in converting catches, based on official statistics reports, from metric tons to numbers of crab. Once the probability distribution functions were defined, the simulation process consisted of randomly sampling 10000 times, and performing a regression analysis from each sample. The catchability parameter was arbitrarily set at 1.

Abundance of adult males, pubescent and spawning females and female-male ratio in the southeastern Gulf of St. Lawrence:

Crab movement from the northwest towards the southeastern area of the sGSL throughout their life cycle was discussed at the 2001 RAP session as one of the causes for the differential stock fluctuation pattern between southwestern Gulf (Areas 12 and 12E) and southeastern Gulf (Cape Breton corridor portion of Areas 12, 18, 19 and 12F). Subsequent analyses on geographic distribution of different instars revealed that the snow crab population was distributed without interruption between the two units (Moriyasu et al., 2001). However, it is thought that this approach is still valid especially when assessing global trends in the southeastern Gulf because of possible active seasonal migration of crab within this unit. The boundary between the two units was set at 62°10 '(Fig. 1) based on the historical fishing effort and fishable biomass distributions.

Within the southeastern unit, the abundance indices of pubescent and spawning (primiparous and multiparous) females were estimated to verify the female-male ratio. The female-male ratio was calculated as the quotient of functionally mature females and males (ready to mate) (Emlen and Oring, 1977). For snow crab, the ratio was calculated as a half of the abundance of mature females on the

abundance of adult males with a CW larger than 95 mm. The females that are ready to mate in the subsequent mating season have to carry developed eggs during the survey period (July-September). However, it is difficult to distinguish between clear orange eggs 3-7 month earlier from dark orange eggs 15-17 months earlier during the summer trawl survey onboard the survey vessel. Therefore, half of the abundance of mature females was used as an approximation for the abundance of spawning females carrying well developed embryo based on the assumption of a 2-yr embryonic development cycle (Moriyasu and Lanteigne, 1998). This ratio represents the female-male ratio for the re-mating sequence (adult males ≥ 95 mm CW vs. multiparous females) in the following spring. For the first mating sequence (adult males vs. pubescent females), the female-male ratio was calculated as a quotient of the abundance of pubescent females on the abundance of either total adult males or those with a CW ≥ 95 mm.

Results and Discussion

Fishery information:

The 2003 fishing season started July 7th and closed September 6th with a total quota of 3,106 t. From June 2th to July 4th, four vessels fished approximately 90.7 t in order to collect funds for the DFO/Area19 agreement. In 2003, landings reached 3,103 t (Table 1, Fig. 4). The traditional and temporary fishermen caught their quota by the 9th fishing week. Seventy-three temporary fishermen started fishing on July 7th with an individual quota of 8.4 t (18,602 lbs). The average CPUE in 2003 was 103.6 kg/trap haul (kg/th), which represents an increase of 43.5% compared to 2002 (Table 1). The weekly CPUE was 175.9 kg/th during the first week of the fishery and then gradually decreased to 45.9 kg/th by the 9th fishing week (Fig. 5). The fishing effort in 2003 (29,952 trap hauls) was 46% lower than the 2002 season (Table 1). The fishing effort was widely spread all over Area 19 including the northern (hard bottom) zone (Fig. 6). The 2003 landings mainly came from the central and southern parts of Area 19 (Fig. 7) while the CPUEs greater than 100 kg/th were well distributed throughout the southern part of Area 19 (Fig. 8).

At-sea sampling provided a good coverage of the main fishing grounds in Area 19 in 2003 (Fig. 2). A total of 177 traps were sampled (5.4% coverage) during 105 trips out of 1,961 with 7,016 males measured. The weekly percentage of soft-shelled crabs (Fig. 5) was negligible throughout the season varying between 0 and 8.5%. The seasonal average percentage of soft-shelled crabs was 3.7% in 2003, which is comparable to the 2002 fishing season (3.5%) (Table 1, Fig. 9). According to the soft-shelled crab protocol, there was no closure of grids or sectors within the area because of high incidence of soft-shelled crabs in 2003 (Fig. 10).

The seasonal catch composition from the observer data (Table 2) showed that there was an increase of skip molters in 2003 (10.5%) compared to 2002 (6.9%). There was also an increase in the percentage of adult hard-shelled crabs in 2003 (71.7%) compared to 2002 (64.0%) while the sub-legal adult hard-shelled crabs decreased in 2003 (14.0%) compared to 2002 (26.7%). The percentage of commercial-sized adult males (Table 3) of carapace conditions 1 and 2 in 2003 (4.9%) decreased compared to the 2002 season (8.8%), while the percentage of commercial-sized adult males of carapace condition 3 increased in 2003 (80.4%) compared to the 2002 fishing season (70.2%). The percentage of commercial-sized crab (carapace condition 4) has continuously increased between 1997 and 2001, but significantly dropped to 14.5% in 2003. Commercial-sized crabs with a carapace condition 5 have been at a stable level between 0.2 % and 0.8% in the past five seasons. The mean CW has been continuously decreasing from 1995 to 2002 from 120.5 mm to 110.0 mm but has increased to 114.0 mm CW in 2003 (Fig. 11). In addition, a bi-modal distribution pattern has appeared from 2000 to 2002 compared to a uni-modal distribution pattern in 1997-1999 (Fig. 12) with a pronounced decrease in the larger-sized component towards 2002. In 2003, a uni-modal distribution pattern was also observed with a significant shift towards larger-sized adult males. The adolescent component was also much larger in 2003 compared to those observed in 2002 and 2001 (Fig. 12). Fragmentation of the histograms in 2003 into carapace conditions (Fig. 13) showed that the main component of the catches was the adult male of carapace conditions 3 and 3m. A smaller mode group of sub-legal adult males of carapace conditions 4 and 5 was observed in the catches. This may have been caused by at-sea size sorting activities (discarding undersized males) resulting in an accumulation of older sub-legal-sized adult males over the years.

Comparison of the swept area between the two survey vessels:
The comparison of the swept area by the *Nephrops* trawl between the "Marco-Michel" in 2003 and "Den C. Martin" in 2002 revealed that the mean swept area was significantly higher (*t*-test; $P < 0.0001$) with the "Marco-Michel" (mean value of 2,910 m^2, S.D. = 610 m^2) compared to the "Den C. Martin" (mean value of 2,580 m^2, S.D. = 605 m^2). The net opening and tow distance were significantly higher (*t*-test; $P < 0.0001$ in both cases) with the "Marco-Michel" (mean net opening of 9.41 m, S.D. = 1.84 m; and mean tow distance of 309 m, S.D. = 21.3 m) than that of the "Den C. Martin" (mean net opening of 8.68 m, S.D. = 1.8 m; and mean tow distance of 296 m, S.D. = 31.9 m). The comparison of the mean boat speed per tow showed that the "Marco-Michel" (mean boat speed per tow = 1.04 m/s, S.D. = 0.053 m/s) maintained a higher and more constant speed (*t*-test; $P < 0.0001$) than that of the "Den C. Martin" (mean boat speed per tow = 0.92 m/s, S.D. = 0.080 m/s). Although, there was a significant difference in the mean *Nephrops* trawl opening, tow distance and towed speed, we cannot estimate if there is a significant difference in trawl efficiency between the two survey vessels since no side-by-side at-sea catchability comparative study was done.

Discrepancy in commercial biomass index:
A slight discrepancy was observed between the observed and expected values of the commercial-sized adult male abundance since 1993 from the non-linear least squares regression model (Fig. 14). A loss of 1.4% due to natural mortality, emigration or immigration between the time of the trawl survey and the following fishing season was estimated based on this model. It was decided at the 2004 RAP meeting (Anonymous 2004) that even if preliminary attempts were made to quantify this loss or gain of commercial-sized adult males between the time of the survey and the fishing season, more study is needed in order to adequately incorporate this in the stock assessment. In Area 12, the loss of commercial-sized males was estimated at 32%. The difference in the loss of commercial-sized adult males between Areas 12 and 19 indicates an immigration of adult males ≥ 95 mm CW from Area 12 into Area 19. This directional movement of commercial-sized crabs was clearly showed by comparing the results between the September 2001 and June 2002 surveys in Area 19, which showed an incoming biomass to Area 19 after the survey in September and prior to the 2002 fishing season (Hébert et al., 2003a). Moreover, the abundance of prerecruits R-3 and R-2 in Area 19 showed a different pattern than Area 12. Contrarily to Area 12, the abundance of prerecruits R-3 at year (y) was much lower than the abundance of R-2 at year (y + 1) indicating a continuous immigration of these crabs into Area 19.

Trawl survey (biomass, abundance and size distribution):
The commercial biomass index (B) at the time of the 2003 trawl survey was estimated at 8,083t (±18%), which represents an increase of 64% compared to the 2002 estimate (4,930 t ± 30%) (Table 4, Fig. 15). This commercial biomass index is the highest value ever recorded since we started conducting the trawl survey in 1991. The two main patches of concentrations were observed in the southern and middle parts of the area showing a similar pattern compared to that of 2002 (Fig. 16). The index of recruitment to the fishery (R) was estimated at 4,073 t (± 24%), which represents an increase of 39% compared to 2002 (2,927 t ± 47%). The 2003 recruitment index represents 50% of the total commercial biomass index. Since 1991, the abundance indices of R-3 and R-2 were observed at their highest level in 2000 for R-3 reaching 6.8 million of individuals and in 2002 for R-2 at 14.8 million (Fig. 17). In 2003, the abundance index of R-3 and R-2 decreased to 3.2 million and 11.4 million of individuals respectively, which may indicate a decrease in commercial biomass index in the near future. However conversely to what we observed in Area 12, the abundances of prerecruits R-3 at year (y) were much lower than the abundances of R-2 at year (y + 1) indicating a continuous immigration of these crabs into Area 19, which positively affects the recruitment to the fishery in this area each year. The abundance of prerecruits is still high in Area 19 (Fig. 18), which may indicate an increase of soft/white crab if the fishing effort is too high. The biomass index of very old crab, which had continuously increased

between 1999 and 2001, has dropped drastically from 206 t (± 96%) in 2001 to 27 t (±134%) in 2002 but has slightly increased to 174 t (± 50 %) in 2003 (Table 4).

Size frequency distributions of crab caught in the trawl survey (Fig. 19) have been available since 1991. In Area 19, the size distribution pattern seems to be different compared to that of Area 12. There have been continuous appearances of small instars (absence of trough) throughout the years since we did the survey. There was also no evidence of a lack of medium-sized adolescents during these years. In 1991 and 1992, the progression of modes was not apparent. Since 1993, a continuous appearance of many instars and their progression (growth) has been observed. In 1996, six distinct modes (21.5 mm CW, 30.5 mm CW, 42.5 mm CW, 60.5 mm CW, 77.5 mm CW and 93.5 mm CW) of adolescent males corresponding to instars VI, VII, VIII, X, XI and XII were observed. Although the general tendency for the progression of modes was observed between 1996 and 1999, the density of each instar cannot be properly investigated due to the *Nephrops* trawl net selectivity. The continuous appearance of small instars in this area may be explained by: (1) the larvae hatched from females in other areas may be transported towards the southeastern Gulf (J. Chassé, pers. comm.) or (2) the movement (shifting concentrations) of smaller-sized instars from the southwestern to the southeastern area of the sGSL throughout their growth process (Moriyasu et al., 2001). The hypothesis of larval transportation towards the southeastern Gulf from the southwestern Gulf may compensate for years of low recruitment within the southeastern unit, which may result in a continuous supply of larval settlement in this area. Although smaller instars (VI, VII and VIII) seem to appear in abundance, a lower abundance of instars IX and X may result in a decline of fishable stock in the future. This sign of future decline in commercial stock appeared in the abundance index of R-3 and R-2 in 2003. However, these instars were observed in the adjacent Area 12 (Fig. 18). The migration of these instars towards Area 19 might contribute to a higher biomass index in Area 19 in the future.

Female-male ratio in the southeastern Gulf of St. Lawrence:
The abundance index of adult males ≥ 95 mm CW (Fig. 20) increased from 13 to 24 million of individuals from 1991 to 1992. From 1992 to 1995, the abundance index decreased from 24 to 10 million (Fig. 20). Since 1995, the abundance index has continuously increased to reach 29 million in 2003 (Fig. 20). The abundance index of total adult males followed a similar pattern as the adult males ≥ 95 mm CW until 2002 (Fig. 20). In 2003, the abundance index of total adult males decreased to 45 million of individuals (Fig. 20).

The abundance index of pubescent females decreased from 2 to 1 million of individuals from 1991 to 1992 and has increased until 1994 to reach 15 million, then decreased to 3 million of individuals in 1997 (Fig. 20). From 1997 to 2000, the abundance index increased from 3 to 19 million of individuals (Fig. 20). In 2001, the abundance index decreased to 8 million of individuals but has since

gradually increased to reach 14 million of individuals in 2003. In 2003, the main concentrations of pubescent females in the southeastern Gulf of St. Lawrence were located in the northern part of Area 19 and the Cape Breton Corridor (Fig. 21).

The abundance index of spawning females was at its highest level (72 million) in 1991, but decreased significantly to 25.5 million in 1993 and then increased to 38 million of individuals in 1995 (Fig. 20). From 1996 to 1998, the abundance index of these females fluctuated between 26 and 35.5 million of individuals. The abundance index of these females had decreased to 27.5 million of individuals in 1999 but has gradually increased to reach 43 million of individuals in 2002 (Fig. 20). In 2003, the abundance index of spawning stock has slightly decreased to 42 million of individuals (Fig. 20). The main concentrations of spawning females in 2003 were located mostly in the southern and middle parts of Area 19 (Fig. 22).

The female-male ratio, within the southeastern Gulf, between pubescent females and all adult males or adult males ≥ 95 mm CW has always been close to or less than 1 female vs. 1 male (1:1) since 1991 (Fig. 23). For the spawning females, the female-male ratio was highly biased towards female dominance (6:1 in 1991 and 4:1 in 1995). Except for these two years, the ratio varied between 3:1 (1997-1999) and 2-1.5:1 (1992-1994, 2000-2003) (Fig. 23).

The current abundance of pubescent females in the southeastern Gulf is increasing which may increase the abundance of mature females in the near future. Therefore, there is no sign of decline in spawning population for the near future. Orensanz et al. (1998) stated that "crab stocks offer a unique opportunity to monitor and timely detect signs of recruitment overfishing, based on expedient and objective analysis of female clutch size variation in time and space". Hébert et al. (2003b) showed that a biased female-male ratio may result in a lesser reproductive output (less fecundity), especially in multiparous females. The female-male ratio in the southeastern Gulf seems to be better compared to the southwestern Gulf (Hébert et al., 2003b). However, there was no assessment of reproductive output (e.g. fecundity study) in the southeastern Gulf, and the population reproduction potential cannot be fully assessed. In addition, there is no evidence of local spawning stock vs. recruitment relationship i.e., the early benthic stages on the western Cape Breton fishing grounds may always be fed by larval drifting from other areas. However, no information is available as to the final destination of larvae hatching from females in western Cape Breton. In this context, until the spawning stock vs. recruitment relationship is clearly established, it is recommended to apply a conservative approach in order to promote the enhancement of reproductive potential at a pan-Atlantic level. In the southeastern Gulf of St. Lawrence, an upward trend in abundance of pubescent and new mature females has been occurring, which suggests a necessity for the protection (i.e. lower exploitation) of the larger males with carapace conditions 3 and 4 (the most reproductive group of adult males) to ensure the maximum fertilization of brood.

Using the historical exploitation level of 63 % in Area 19 seems to be beneficial in terms of sex ratio and reproductive output and would also promote an accumulation of residual biomass for the subsequent fishing seasons. Any increase in exploitation compared to the current level in the southeastern Gulf may not improve the population's reproductive potential in the future.

Uncertainty

Change of survey vesssels

A significant difference in the swept area was found between the "Marco-Michel" in 2003 and the "Den C. Martin" in 2002. The biomass and abundance estimates in 2003 may not be comparable with the estimates prior to 2002 if the catch efficiency of the *Nephrops* trawl with the new vessel is different than the former vessel. Without a comparative study between these two vessels to elucidate the catch efficiency of the trawl, the biomass and abundance estimates have to be interpreted with caution.

Seismic survey

In December 2003, seismic testing was conducted by Corridor Resources Inc. in Area 19 and adjacent waters. This seismic study was done after the annual snow crab trawl survey of Area 19 in October 2003. According to Hébert et al. (2002), the crab concentration into the Cape Breton Gully occurs between the fall and the following fishing season in July based on the results of a double trawl surveys. There is no knowledge yet on the possible effect of this seismic testing activity on commercially exploitable crabs. If there is any effect on crab behavior, especially immigration to the Cape Breton Gully, the level of exploitable biomass may have been influenced by the seismic activities. An additional trawl survey prior to the next fishing season would be useful to measure any unusual changes in the abundance of commercial-sized crabs.

Growth

Although the percentage of adolescent males in commercial catches is not at an alarming level (10.9 % in 2002 and 7.2 % in 2003), it would be beneficial for commercial fishing and the enhencement of reproductive potential to protect adolescent males (either skip molter or postmolt adolescent males) especially when the main component of this group is large-sized animals as seen in the 2003 fishery. A portion of these animals will molt again the following molting season as adult males of larger size with more commercial value and higher reproductive potential. The snow crab fishery in Area 19 should be closed as soon as the percentage of soft-shelled crabs exceeds 20% in commercial catches by following the soft-shelled crab closure protocol described in this document.

Environmental conditions

Environmental factors, such as water temperature, can affect the molting and reproductive dynamics as well as the movement of crab. Chassé et al. (2004) reported that the bottom temperatures over most of the sGSL are less than 3 °C, which is considered ideal thermal habitats for snow crab. Chassé et al. (2004) reported that the bottom temperatures in Area 19 are typically 1°-2 °C warmer than the traditional crab grounds in Area 12. For example, approximately 80% of the trawled area during the snow crab survey in Area 12 in 2003 was covered by water of temperatures of < 1.0 °C whereas in Area 19, it was < 2.5 °C. Near-bottom temperatures at most depths in Area 19 during 2003 were generally observed to be colder than the long-term (1971-2000) average and decreased relative to 2002. This is consistent with the increase in the Gulf wide snow crab habitat index (area of the bottom covered by water temperatures between –1 and 3 °C) and the decrease in the average temperature within this area. With this decrease, the temperature conditions are considered more favorable for snow crab than in 2002, although the habitat index is still below the normal.

Prognosis

Area 19

Negative elements:

- The prerecruits R-3 and R-2 have been decreasing since 2001, which may indicate a decrease in commercial biomass index in the near future if no immigration of adult males ≥ 95 mm CW occurs in that area.
- The pubescent females increased in 2003. As such, any increase from the exploitation level adopted for the 2003 season may not be beneficial to the long-term reproduction of the stock.

Positive elements:

- The CPUE in 2003 (103.6 kg/th) increased by 43.5 % compared to the 2002 season (72.3 kg/th).
- The mean size of commercial-sized adult males increased in 2003 (114.0 mm CW) compared to 2002 (110.0 mm CW).
- The fishing effort decreased by 46 % in 2003 (29,952 trap hauls) compared to 2002 (43,662 trap hauls).
- The commercial biomass and recruitment to the fishery indices significantly increased in 2003.
- The female-male ratio seems to be in better condition compared to the southwestern Gulf of St. Lawrence population (but see #2 in negative elements).

Recommendations:

- For 2003, it is strongly recommended to follow the soft-shelled crab protocol in order to protect the future recruitment to the fishery.
- Using the historical exploitation level of 63 % seems to be beneficial in terms of female-male ratio and reproductive output and would also promote an accumulation of residual biomass for subsequent fishing seasons. Any increase in exploitation compared to the current level may not improve the population's reproductive potential in the future.

Research Recommendations

- A double trawl survey (regular fall and pre-fishery spring surveys) provided important information on the seasonal movement of adult males and is worth trying regularly in the future to verify the seasonal migration and to quantify the incoming migration into the Cape Breton Gully (Area 19);
- Enhance monitoring of the key events on the population reproductive output has to be done in the southeastern Gulf of St. Lawrence (fecundity, spermathecal load, recruitment to the early benthic stages).

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Table 1. Catches, fishing efforts and catch per unit of effort (CPUE) and average percentage of soft-shelled crab in Area 19 between 1987 and 2003.

Year	Quota (t)	Catch (t)	Effort (# of trap hauls)	CPUE (kg/trap haul)	Soft-shelled %
1987	1,150	1,151	37,987	30.3	-
1988	1,338	1,337	22,794	58.7	-
1989	1,338	1,334	29,978	44.5	-
1990	1,338	1,333	28,422	46.9	19.4
1991	1,338	1,337	16,733	79.9	5.1
1992	1,686	1,678	17,140	97.9	6.6
1993	1,686	1,678	18,204	92.2	1.9
1994	1,686	1,672	24,495	68.3	5.5
1995	1,577	1,575	24,854	63.4	3.5
1996	1,343	1,342	24,583	54.6	10.8
1997	1,386	1,386	21,930	63.2	11.1
1998	1,991	1,988	31,232	63.1	11.2
1999	1,986	1,979	19,088	103.7	4.1
2000	3,370	3,225	55,977	64.1	5.6
2001	3,912	3,910	46,251	88.5	6.5
2002	3,285	3,279	43,662	72.3	3.5
2003	3,106	3,103	29,952	103.6	3.7

s: spring season; f: fall season

Table 2. The catch composition (%) from the sea sampling in 2002 and 2003 in Area 19.

2002

	Soft-shelled crabs			Hard-shelled crabs			Total		
	S	L	Tot	S	L	Tot	S	L	Tot
Legal size	0.3	2.2	2.4	4.2	64.0	68.2	4.5	66.1	70.6
Sub-legal size	0.0	0.0	0.0	2.7	26.7	29.4	2.7	26.7	29.4
Total	0.3	2.2	2.5	6.9	90.6	97.5	7.2	92.8	100.0

S: adolescent, L: adult, Tot: total

2003

	Soft-shelled crabs			Hard-shelled crabs			Total		
	S	L	Tot	S	L	Tot	S	L	Tot
Legal size	0.3	3.4	3.7	7.9	71.7	79.6	8.3	75.0	83.3
Sub-legal size	0.0	0.1	0.1	2.5	14.0	16.6	2.6	14.1	16.7
Total	0.3	3.5	3.8	10.5	85.7	96.2	10.9	89.1	100.0

S: adolescent, L: adult, Tot: total

Table 3. The overall composition by carapace conditions for adult males ≥ 95 mm CW in Area 19 from sea samples collected since 1999.

Carapace conditions/ Conditions de carapace	1999	2000	2001	2002	2003
1	0.3	2.0	1.8	3.2	2.4
2	4.2	14.6	6.5	5.6	2.5
3	45.2	26.9	31.3	70.2	80.4
4	49.8	55.8	60.1	20.6	14.5
5	0.5	0.8	0.3	0.5	0.2
Total	100	100	100	100	100

Table 4. Biomass index for different stages of male snow crab with 95 % confidence limits in Area 19.

Year	Area 19		
	B	R	OB
1991*	**5,459** ±1,942	**1,279** ± 374	-
1992*	**5,226** ± 2,205	**1,762** ± 885	-
1993	**2,300** ± 621	**672** ± 184	**114** ± 117
1994	**2,598** ± 1,045	**836** ± 227	**110** ± 74
1995	**1,825** ± 376	**280** ± 131	**223** ± 71
1996	**2,190** ± 600	**965** ± 435	**292** ± 95
1997	**3,160** ± 749	**1,953** ± 469	**0** ± 0
1998	**3,152** ± 1,091	**1,901** ± 1,092	**38** ± 125
1999**	**5,351** ± 1,584	**1,830** ± 966	**1** ± 1
2000**	**6,210** ± 1,118	**4,328** ± 952	**126** ± 49
2001**	**5,214** ± 1,689	**2,927** ± 1,373	**206** ± 197
2002**	**4,930** ± 2,560	**2,947** ± 2,402	**27**± 63
2003***	**8,083 ±** 1,455	**4,073 ±** 978	**174 ±** 87

B: CW ≥ 95 mm with a hard carapace (projected); R: Annual recruitment to the fishery (projected); OB: CW ≥ 95 mm with a very old carapace (direct).

* Survey conducted between the two fishing seasons.

** Biomass estimates from the "Den C. Martin" without adjustment of net efficiency change.

*** Biomass estimates from the "Marc0-Michel" without adjustment of net efficiency change.

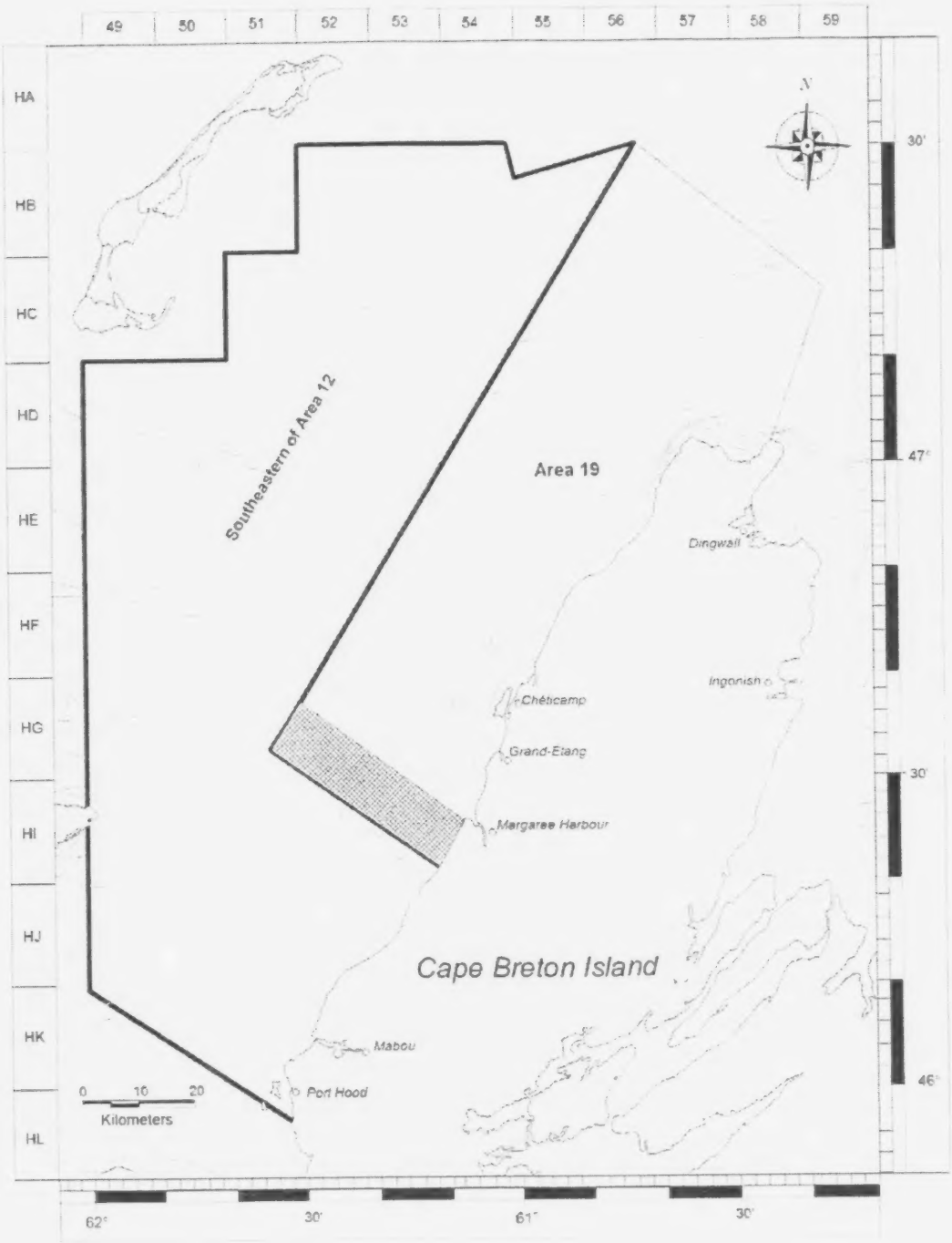

Figure 1. Snow crab management Area 19 and the southeastern part of Area 12 in the southeastern Gulf of St. Lawrence (Southeastern unit of the southern Gulf of St. Lawrence). Shaded area: 5-mile buffer zone.

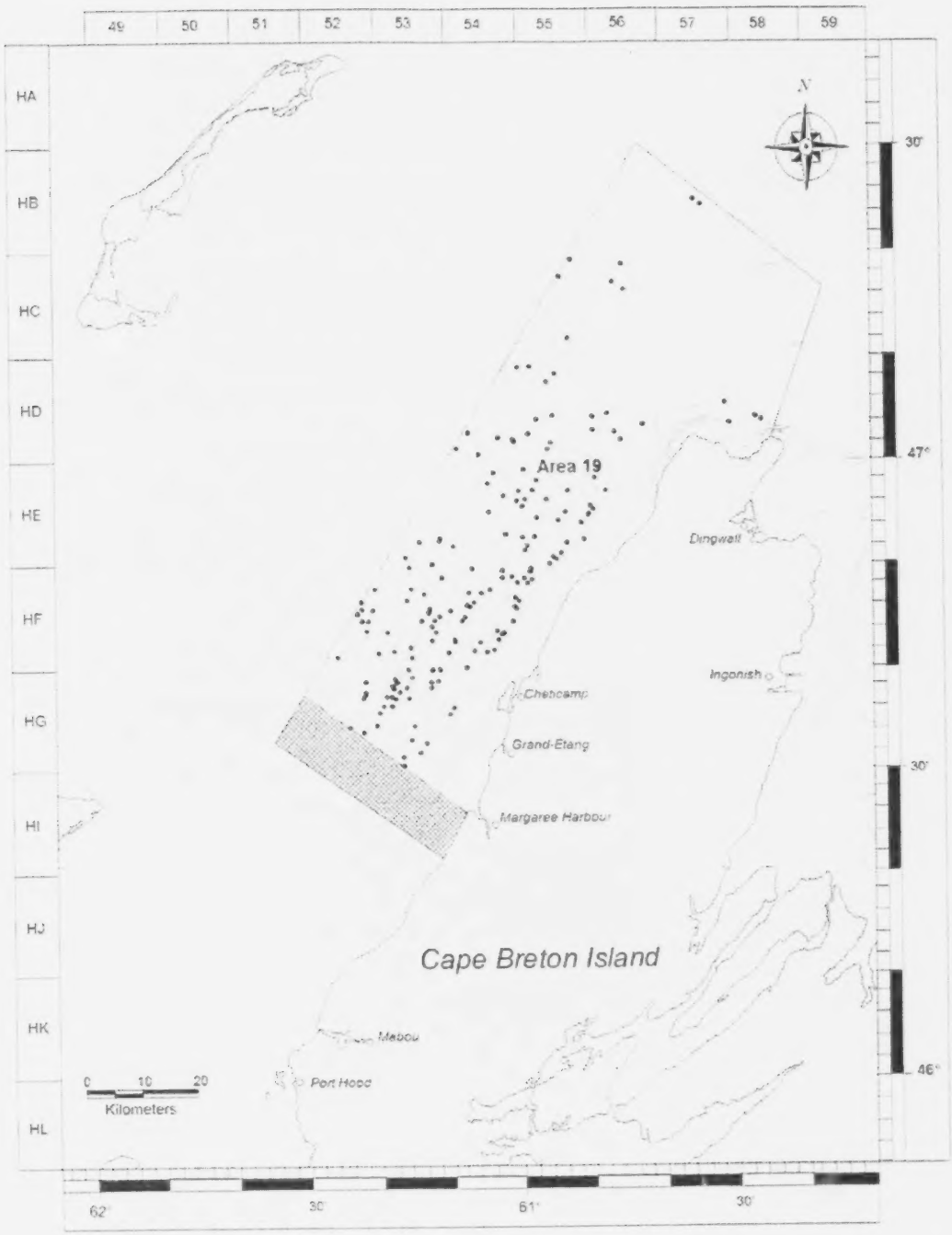

Figure 2. Locations of traps sampled aboard commercial vessels by at-sea observers in Area 19 during the 2003 fishing season (shaded area: 5-mile buffer zone).

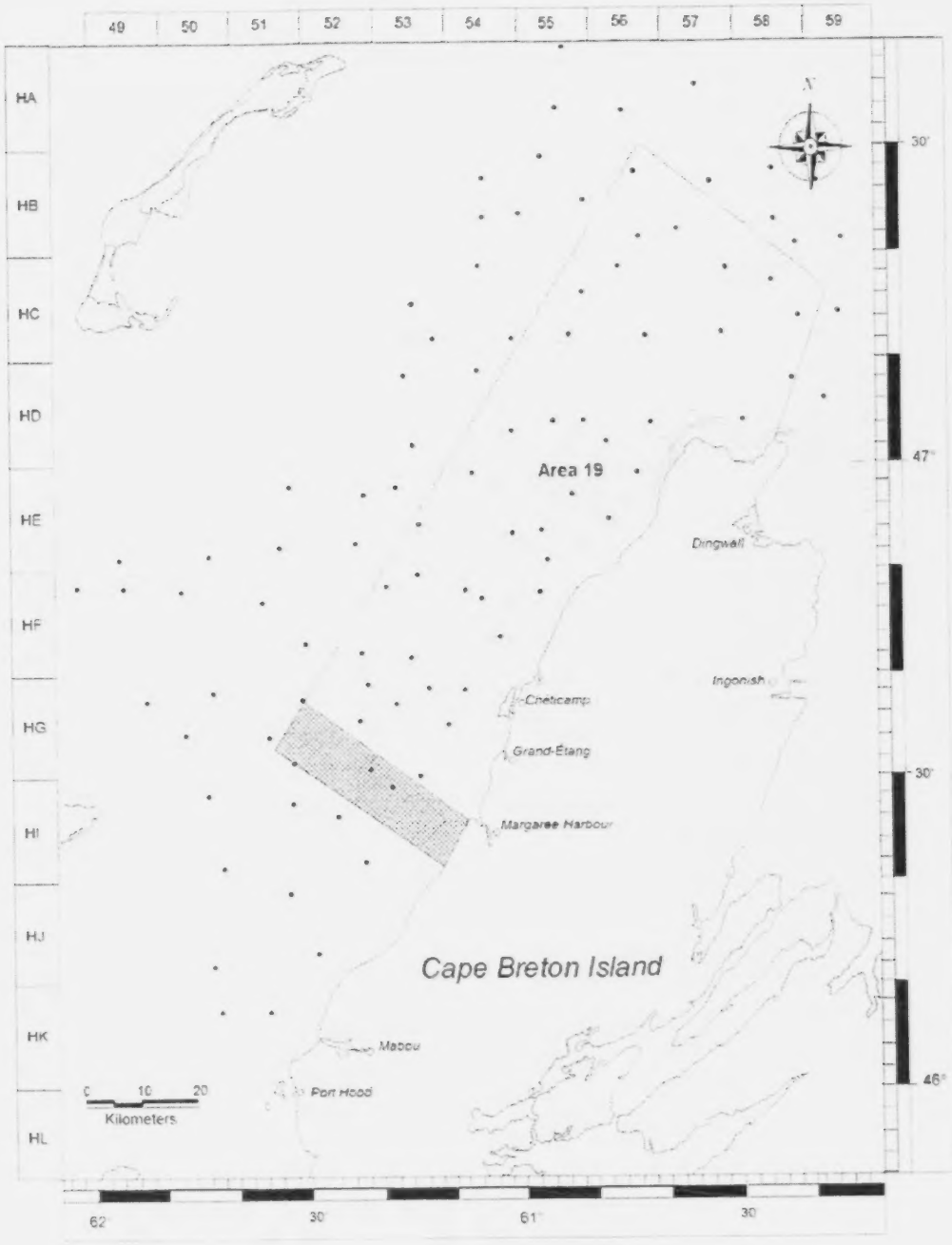

Figure 3. Locations of the 2003 trawl survey stations in Area 19 and adjacent zones (shaded area: 5-mile buffer zone).

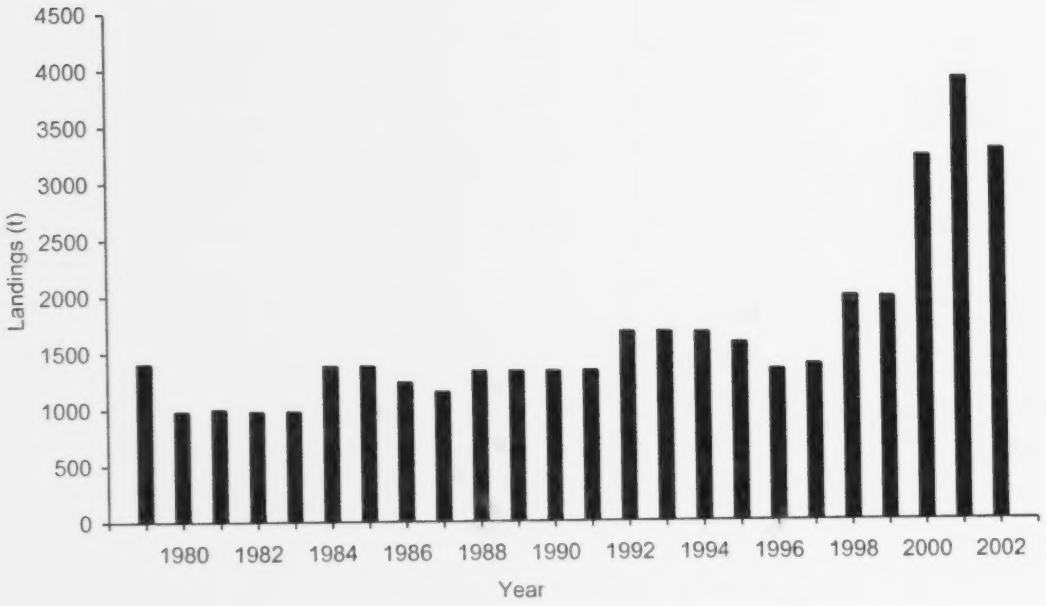

Figure 4. Annual landings in Area 19 between 1979 and 2003.

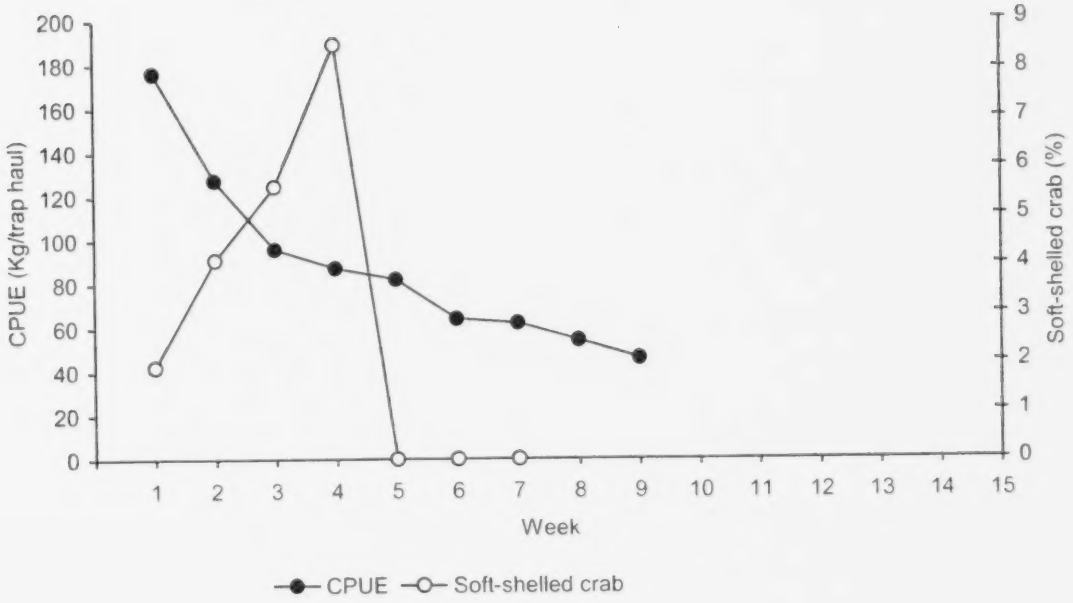

Figure 5. Weekly catch per unit of effort (CPUE) and percentage of soft-shelled crab in Area 19 during the 2003 fishing season.

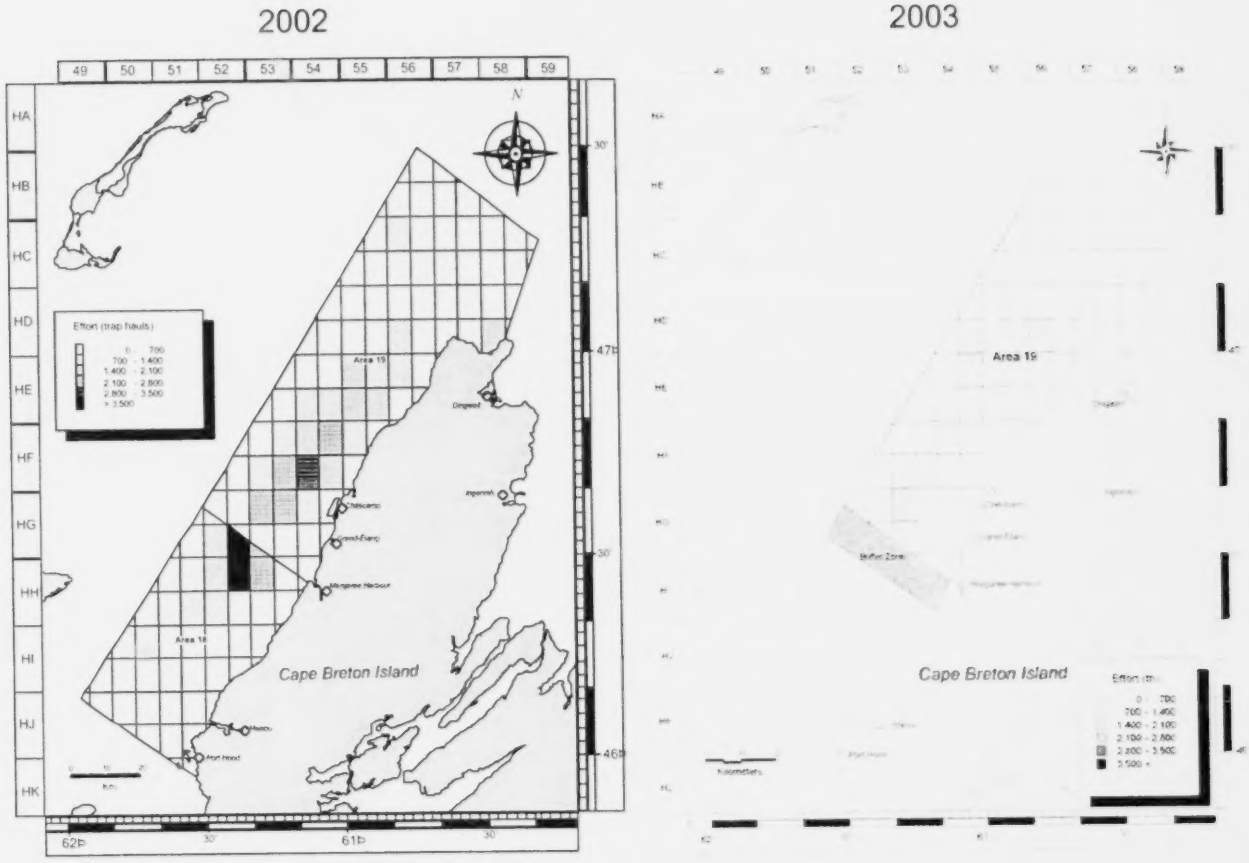

Figure 6. Geographic distribution of fishing effort in Area 19 in 2002 and 2003.

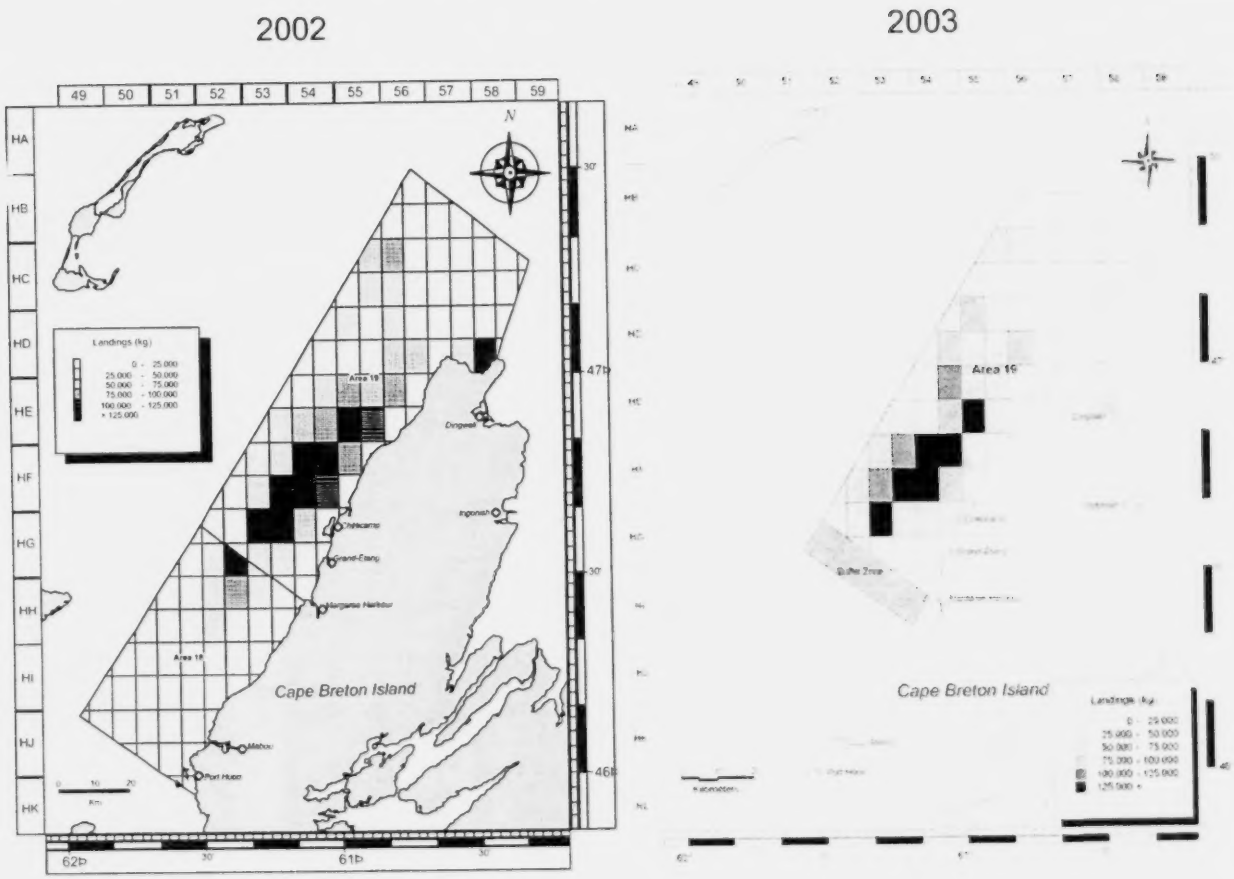

Figure 7. Geographic distribution of landings in Area 19 in 2002 and 2003.

2002

2003

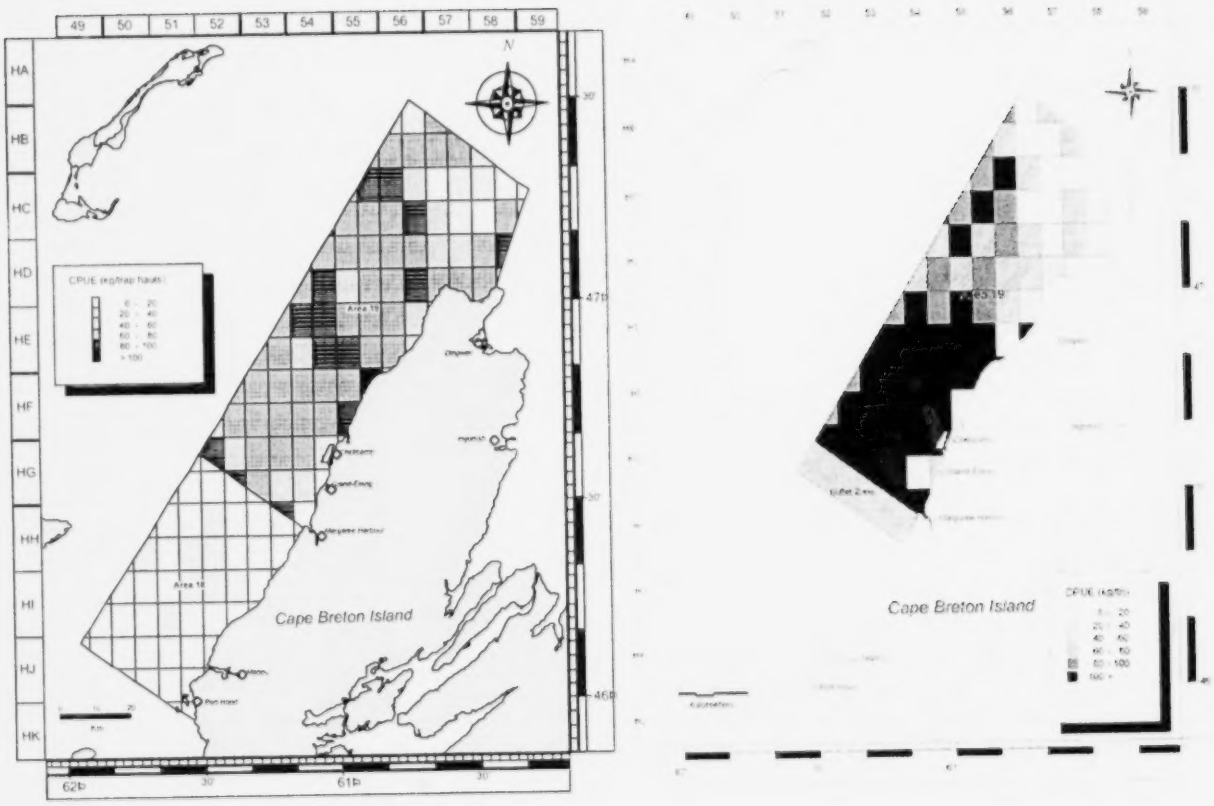

Figure 8. Geographic distribution of mean CPUE (kg/th) in Area 19 in 2002 and 2003.

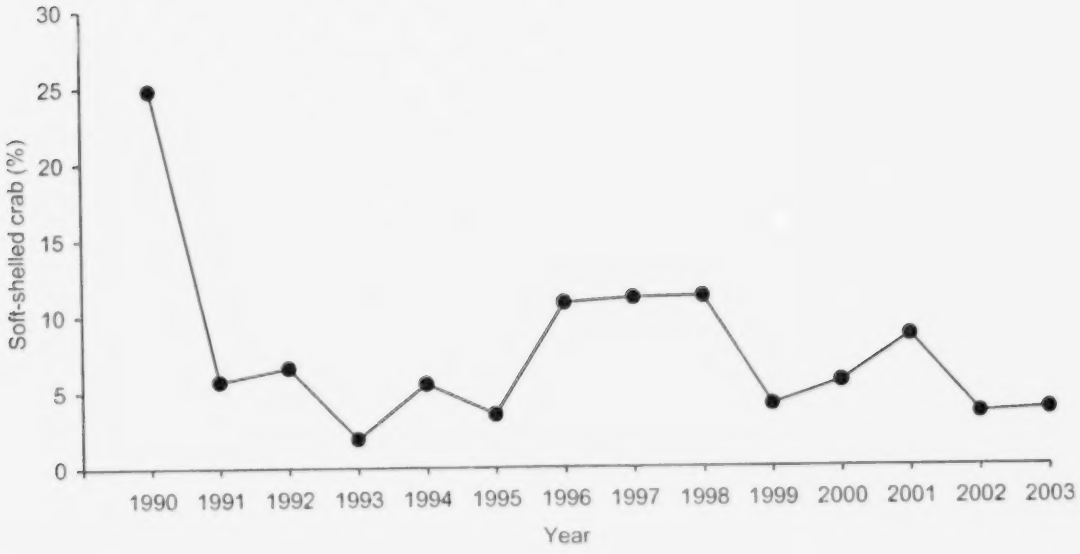

Figure 9. Annual percentage of soft-shelled crab in Area 19 between 1990 and 2003.

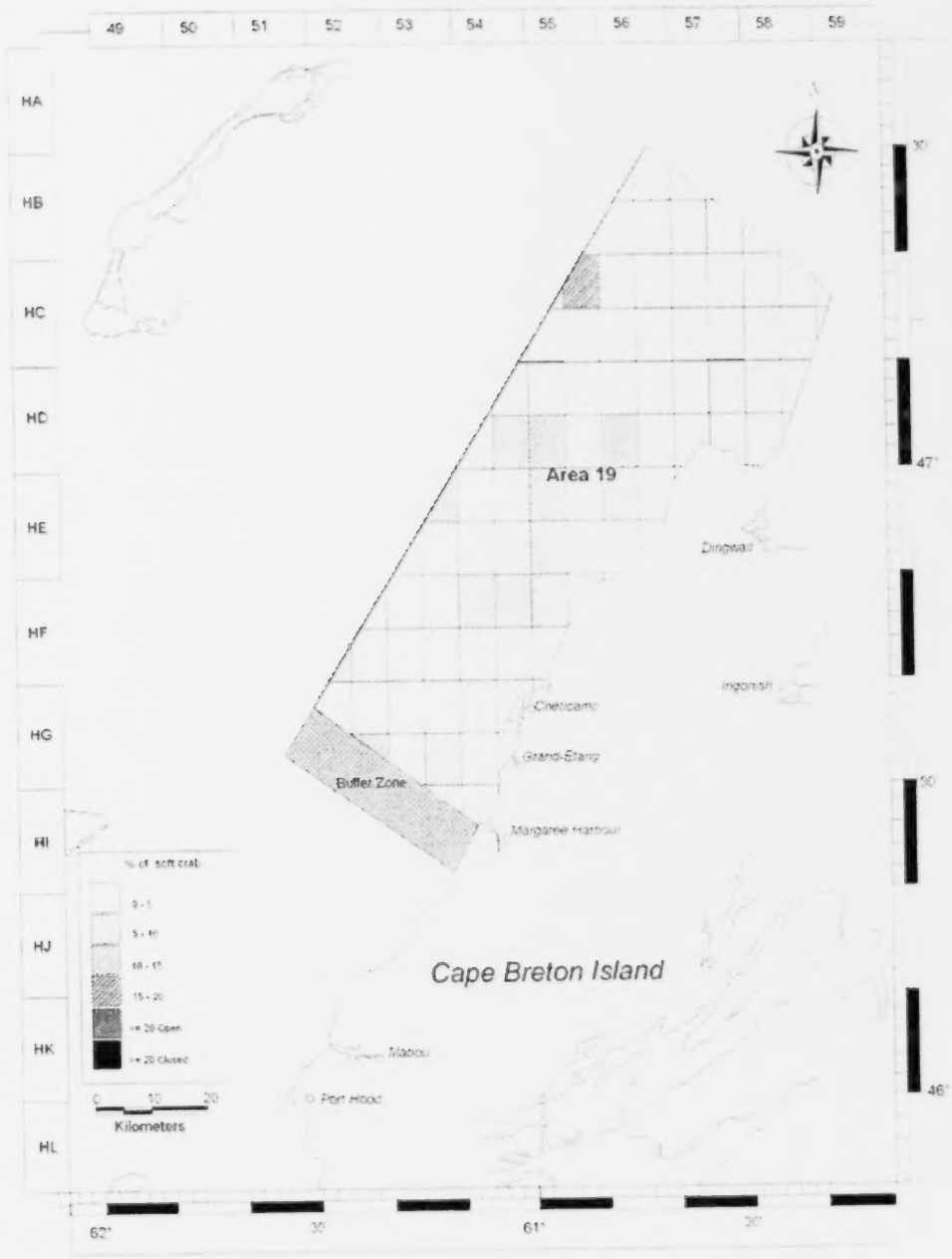

Figure 10. Distribution of soft-shelled crab in Area 19 during the 2003 fishing season.

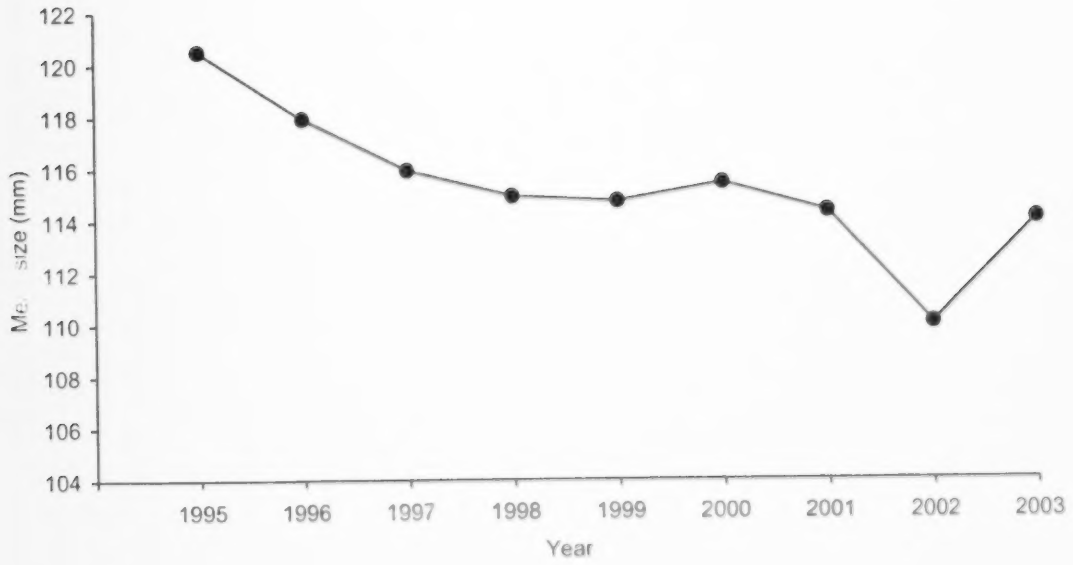

Figure 11. Annual mean size of the commercial catch in Area 19 between 1995 and 2003.

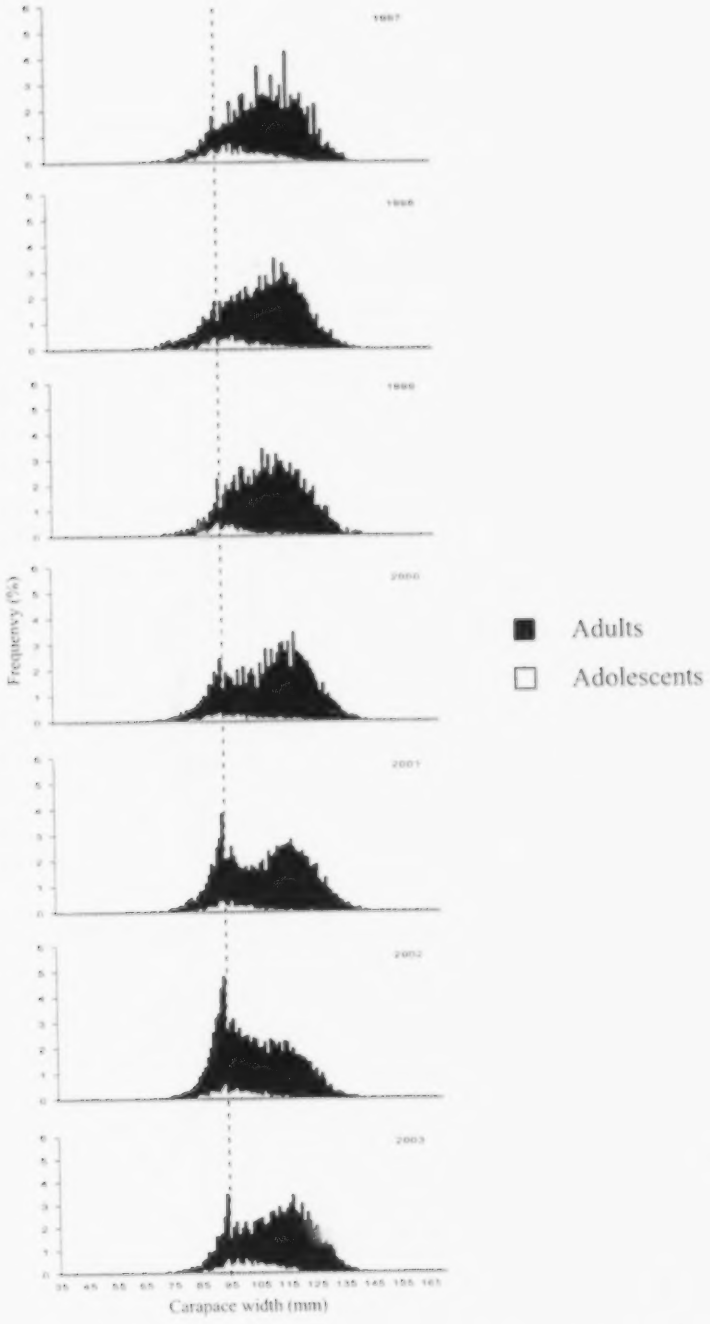

Figure 12. Size frequency distributions of male crabs measured during at-sea sampling in Area 19 between 1997 and 2003 (dotted line indicates the minimum legal size of 95 mm CW).

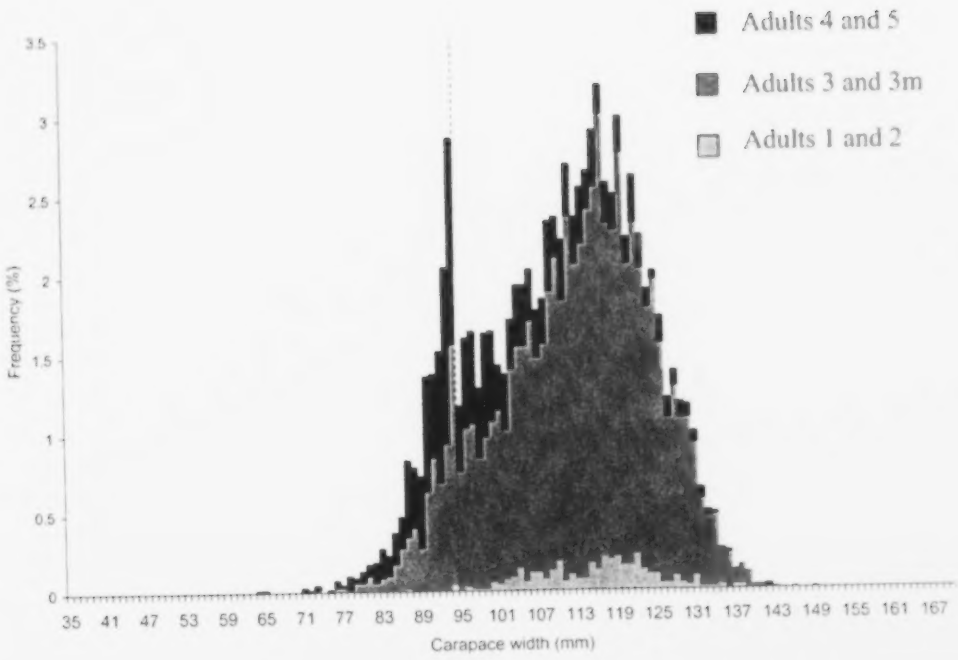

Figure 13. Size frequency distributions of adult male crab by carapace condition in Area 19 during the 2002 fishing season (dotted line indicates the minimum legal size of 95 mm CW).

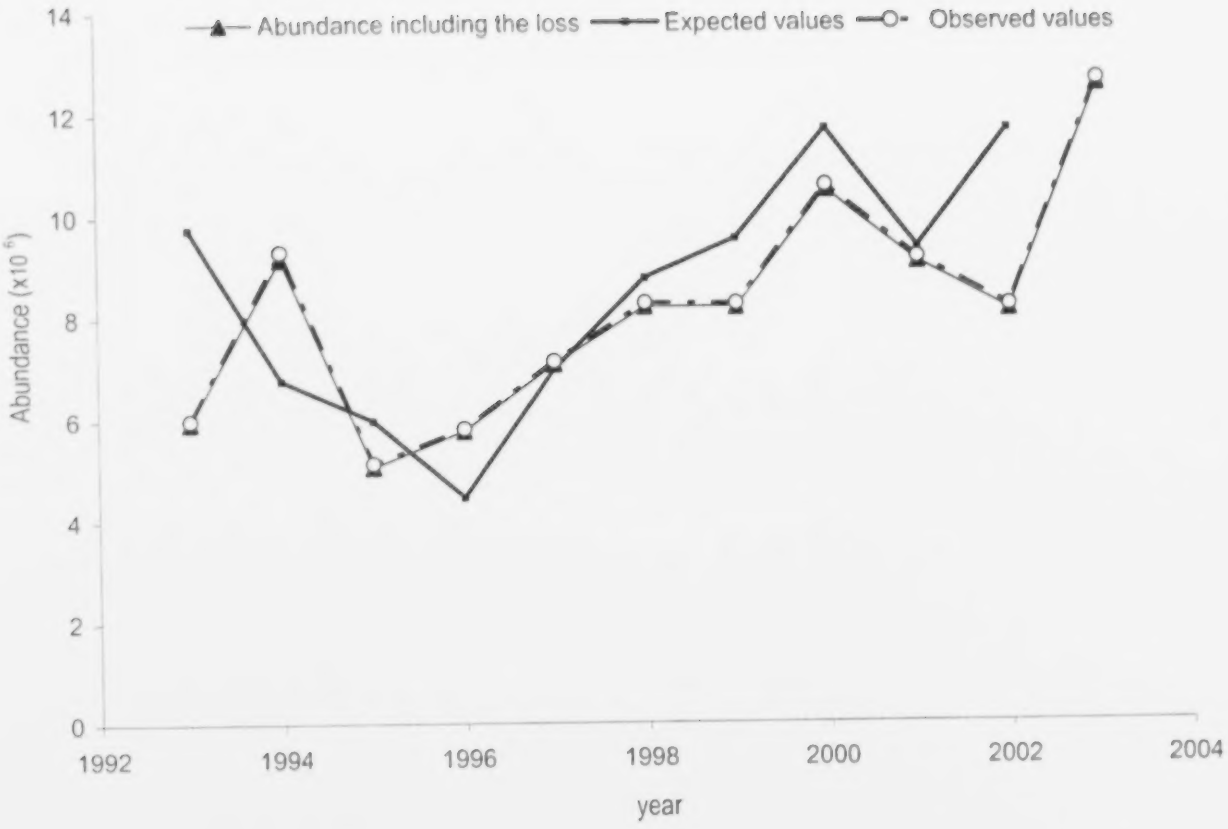

Figure 14. Difference between the observed and expected values of commercial-sized adult males abundance in Area 19 since 1992.

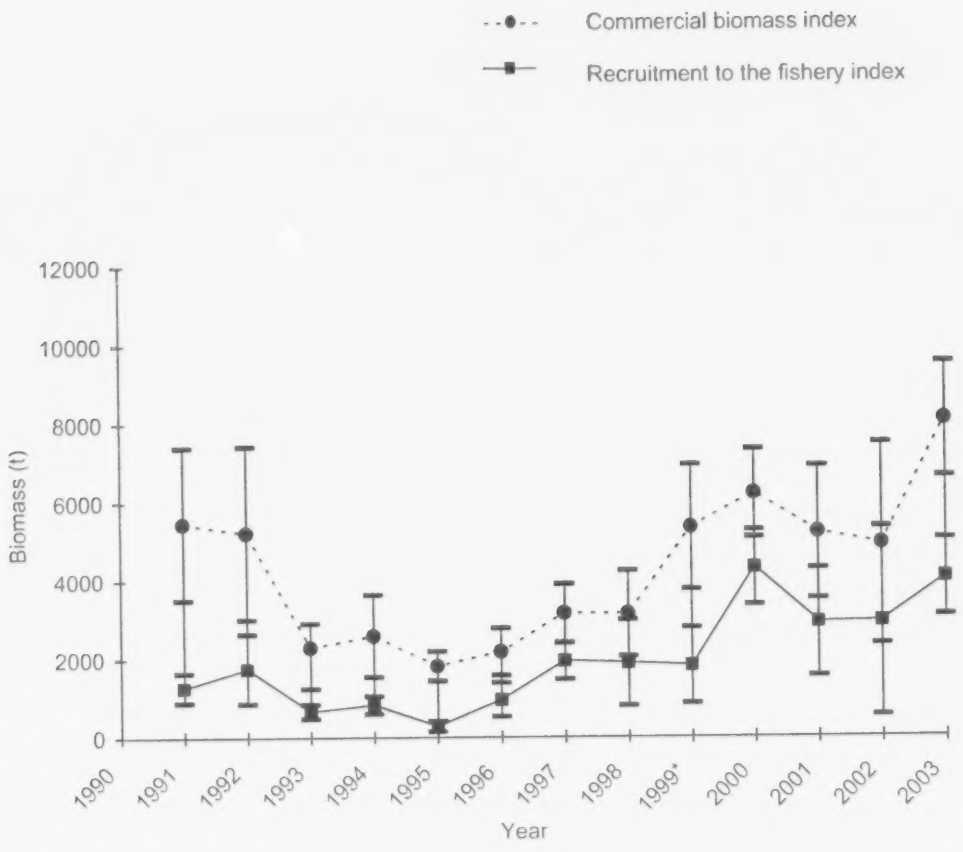

Figure 15. Annual commercial biomass (t) and recruitment to the fishery (t) indices in Area 19 between 1991 and 2003 (1991-1992 trawl surveys were conducted before the fishing season).

* Abundance index in 1999 may not be reliable due to the malfunction of the Netmind system.

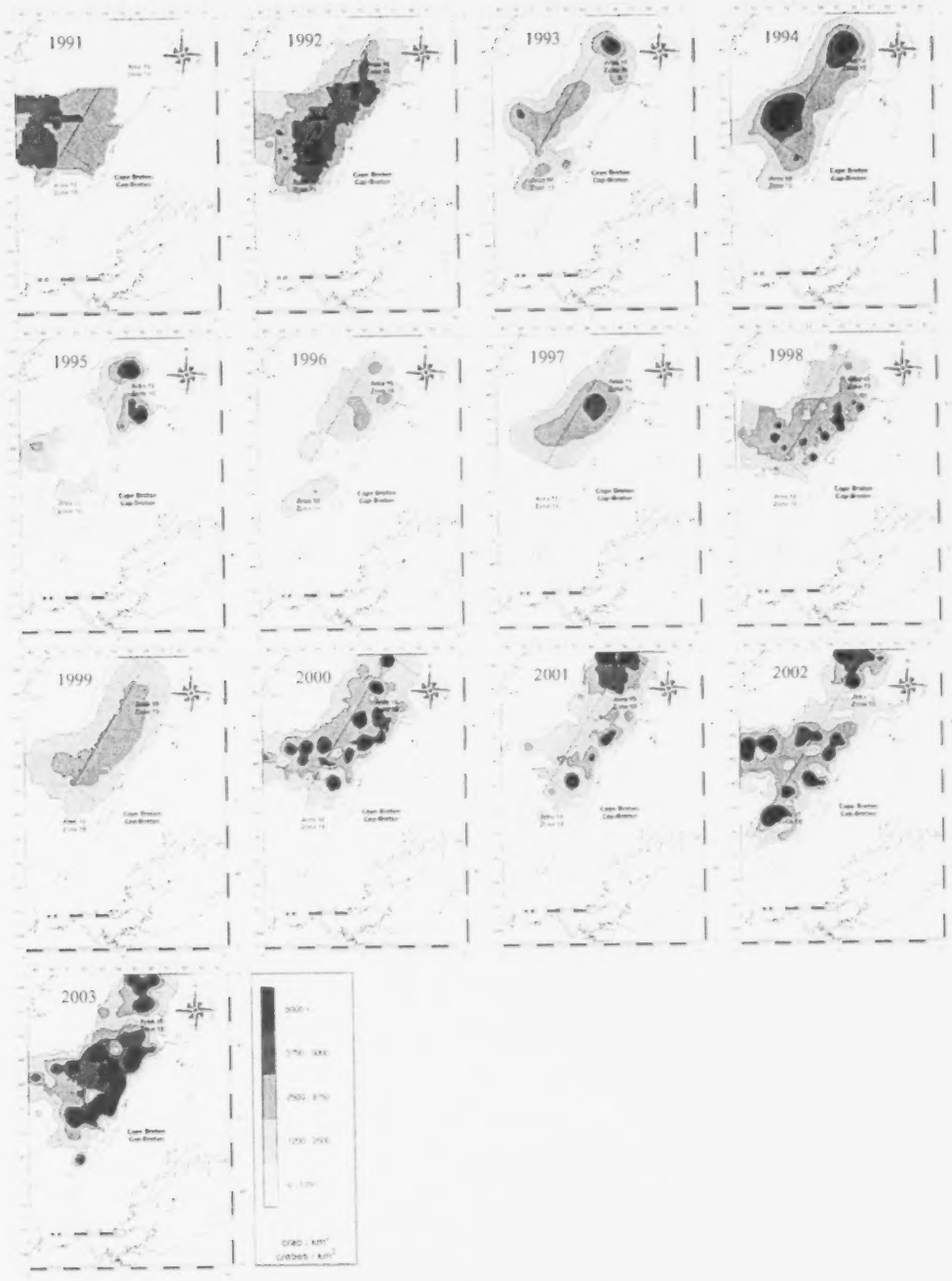

Figure 16. Density contours of adult snow crab of commercial size in the southeastern Gulf of St.Lawrence observed in the trawl survey since 1991.

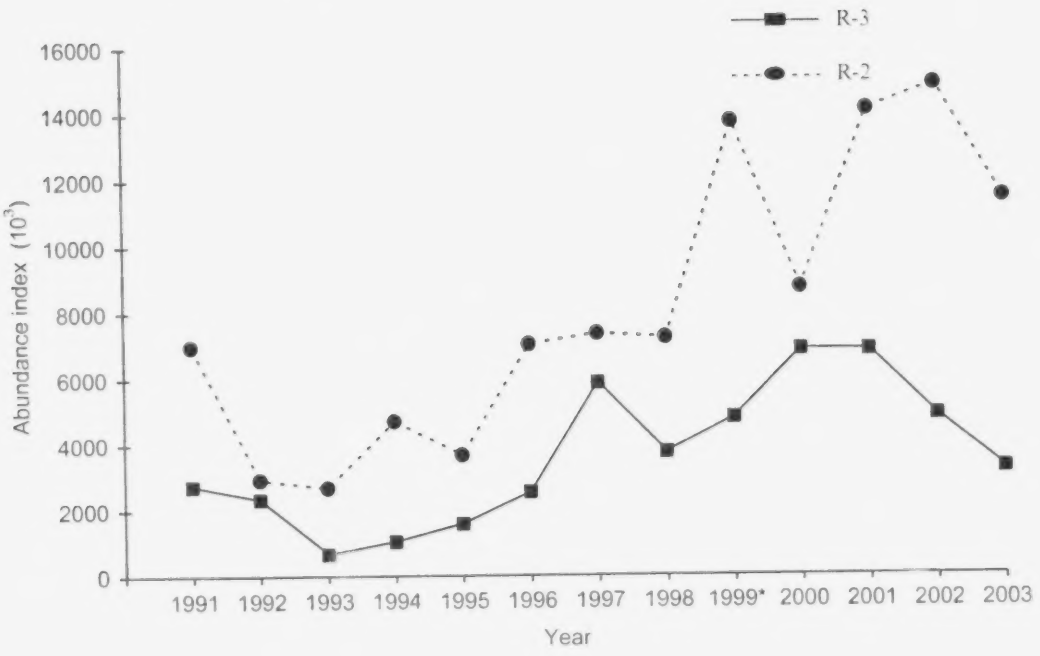

Figure 17. Abundance index of prerecruits R-3 and R-2 in Area 19 between 1991 and 2003.

* Abundance index in 1999 may not be reliable due to the malfunction of the Netmind system.

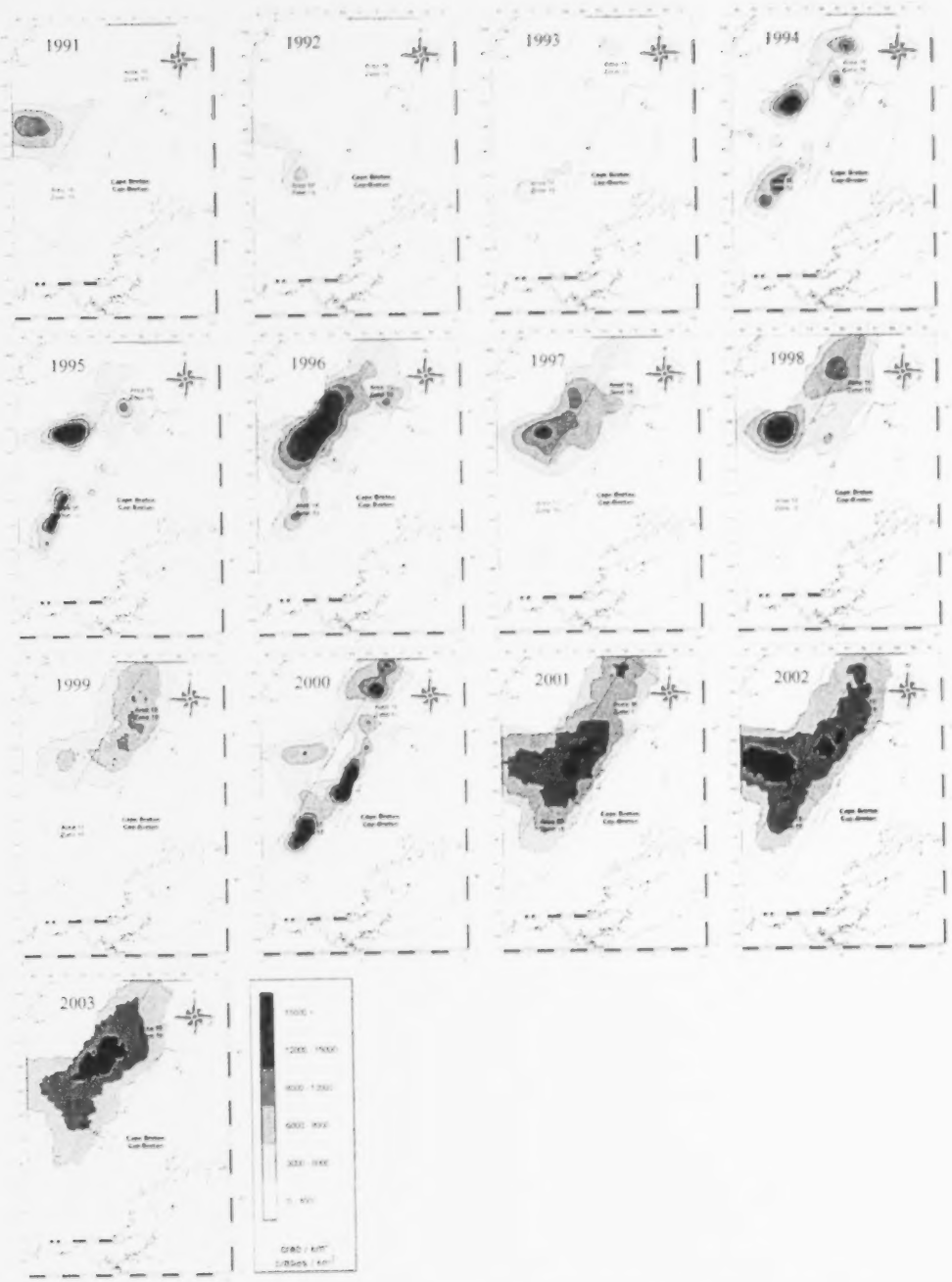

Figure 18. Density contours of adolescent males with CW ≥ 56 mm in the southeastern Gulf of St. Lawrence observed in the trawl survey since 1991.

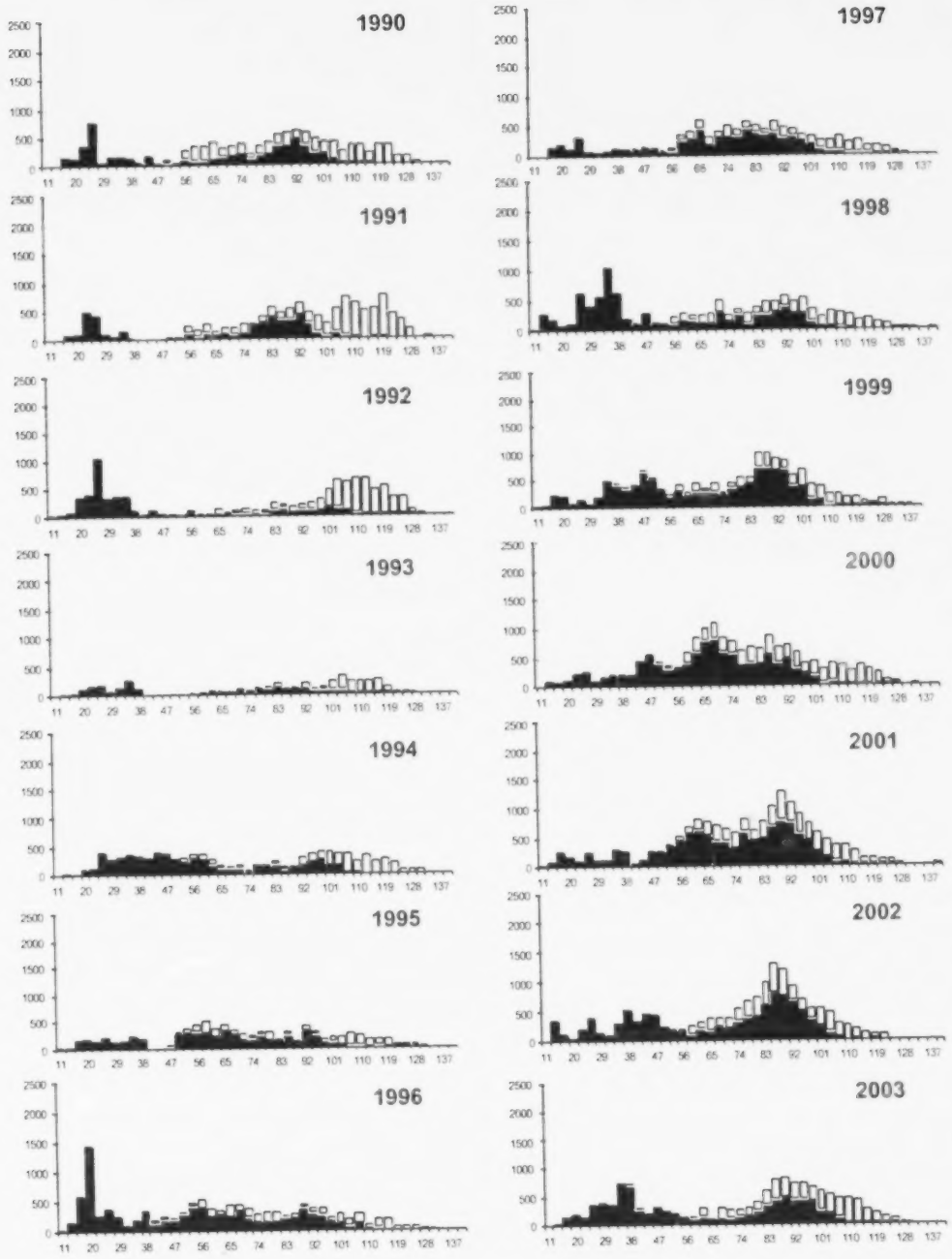

Figure 19. Size frequency distributions for male snow crabs in Area 19 between 1991 and 2003. The 1991-1992 trawl surveys were conducted before the fishing season.

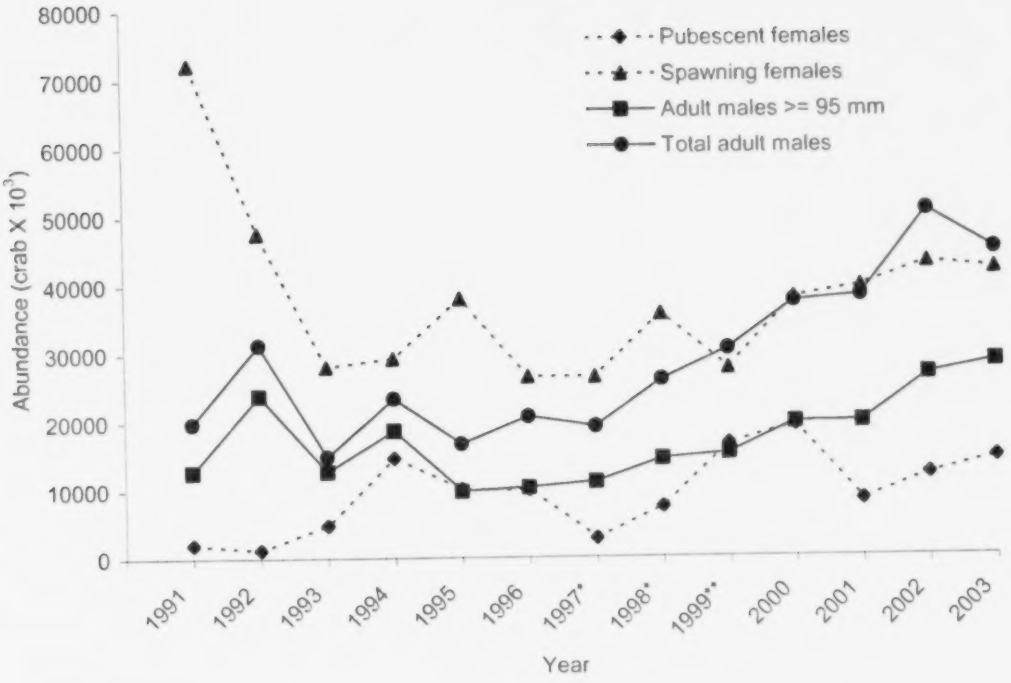

Figure 20. Abundance index of pubescent females, spawning females, adult males ≥ 95mm CW and total adult males in the southeastern Gulf of St. Lawrence between 1991 and 2003.

* No survey in Area 18 between 1997-1998.

** Abundance index in 1999 may not be reliable due to the malfunction of the Netmind system.

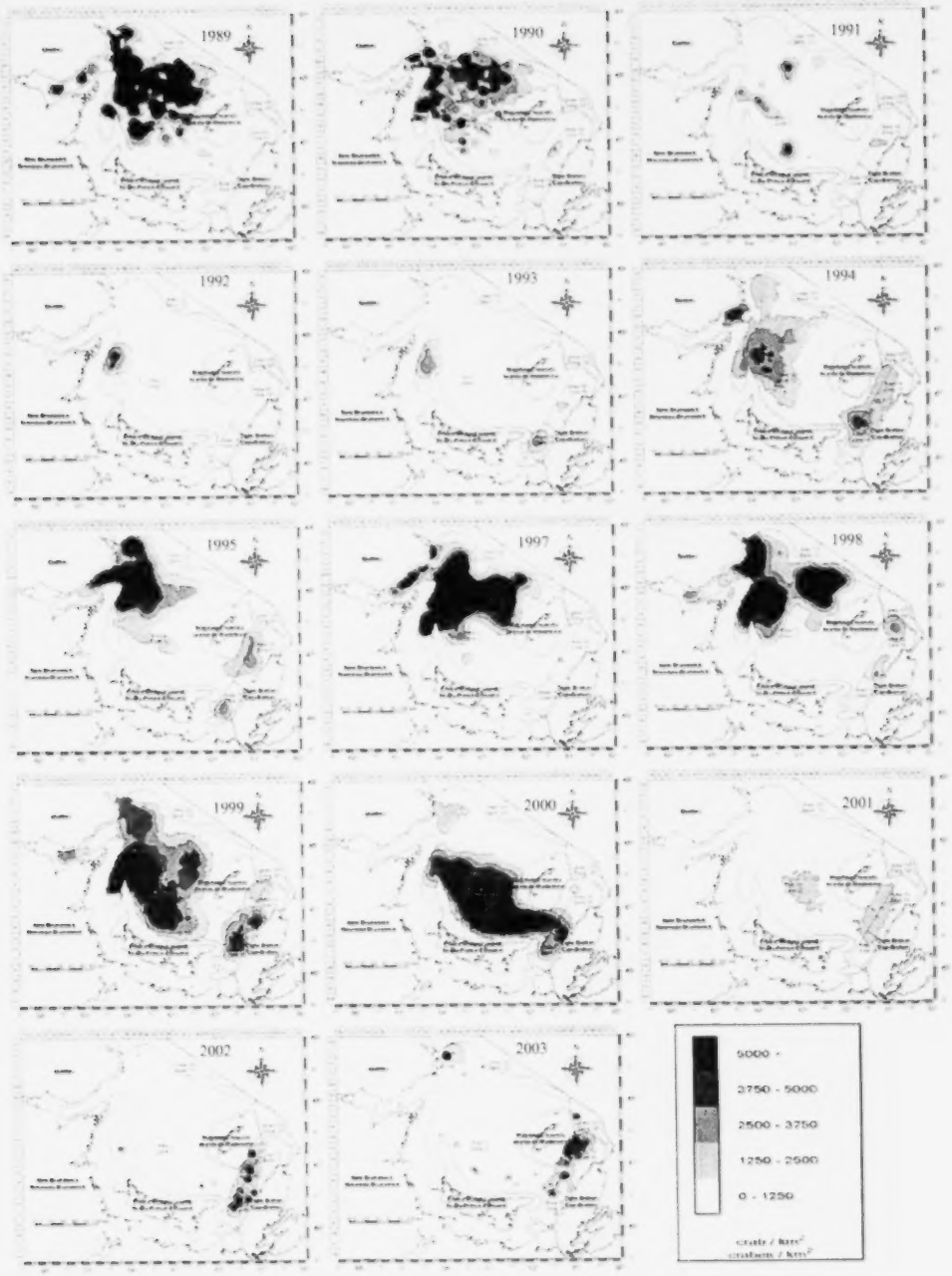

Figure 21. Density contours for pubescent females based on the trawl survey between 1989 and 2003 in the southern Gulf of St. Lawrence.

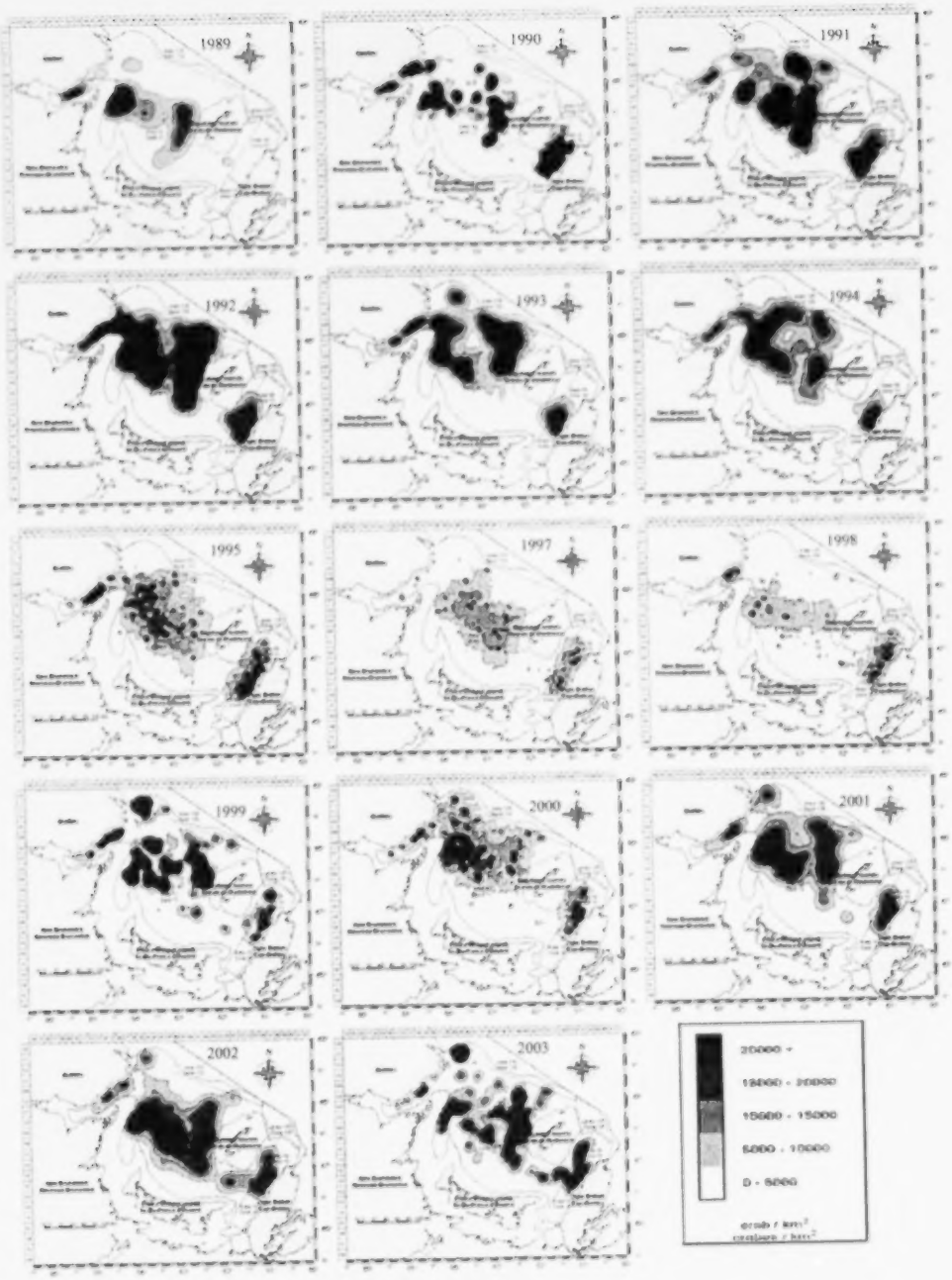

Figure 22. Density contours for mature females based on the trawl survey between 1989 and 2003 in the southern Gulf of St. Lawrence.

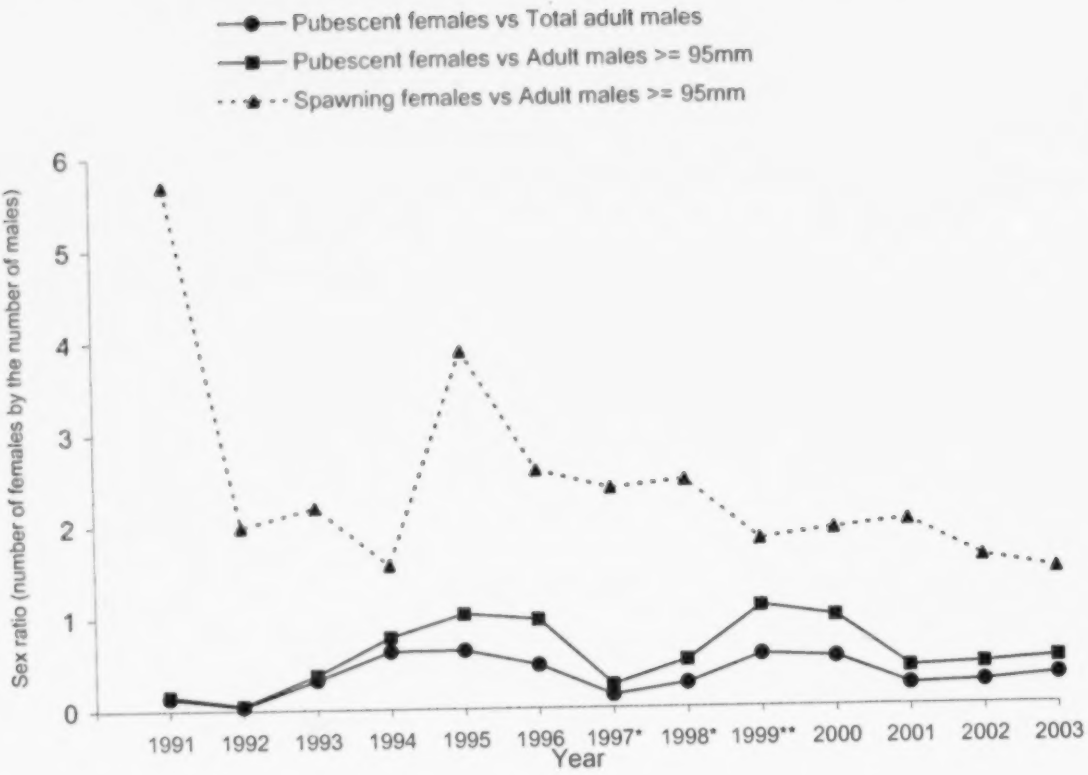

Figure 23. Sex ratio (pubescent females vs total adult males; pubescent females vs adult males ≥ 95 mm CW ; and spawning females vs adult males ≥ 95 mm CW) in the southeastern unit of the southern Gulf of St. Lawrence between 1991 and 2003.

* No survey in Area 18 between 1997-1998.
** Abundance index in 1999 may not be reliable due to the malfunction of the Netmind system.